VERTEBRATE DAMAGE CONTROL RESEARCH IN AGRICULTURE

ANNUAL REPORT FY 92-93

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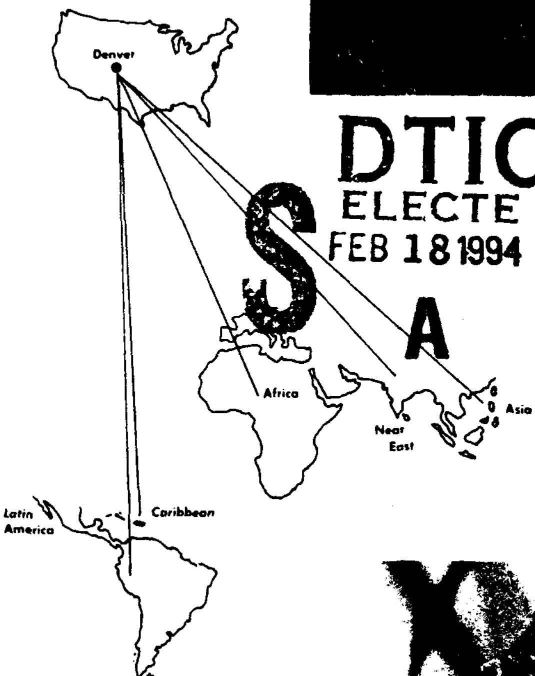

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U.S. Department of Agriculture

Agency for International Development

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THE COVER

The cover illustrates two of the most severe animal damage problems under investigation by the USAID-sponsored International Programs of the Denver Wildlife Research Center (DWRC): rodent and bird damage to agricultural crops both preharvest and postharvest. Research at DWRC and in the field involves evaluating a variety of management methods including chemical, physical, cultural, or other techniques that have potential to provide safe, economical, and environmentally sound methods to reduce vertebrate damage in agriculture. The pest species, crop, farming and storage methods, environmental factors, and a host of other considerations may influence the manner in which a particular problem is addressed.

Vertebrate damage in agriculture involves a variety of crops and species of animals, primarily birds and rodents. Direct losses occur typically at planting and sprouting, during the milk or dough stages (for grains), just before harvest, or during postharvest storage conditions. Field projects have been initiated to conduct studies to find ways to reduce or alleviate this damage in several countries of South and Central America, Africa, and Asia.

In many areas of the world, rodent damage to field crops, such as rice in Asia, severely reduces the human food supply and increases the risks to individual farms. In localized areas, rodents may be a principal factor limiting crop production; often, rodents unobtrusively remove a share of production before harvest—crop after crop, season after season. Although there are more than 1,600 kinds of rodents, only about 50 are considered significant agricultural pests.

Agricultural losses to birds are not as well-documented as those to rodents. Various species of parrots, parakeets, blackbirds, weavers, doves, seed-eaters, pheasants, and waterfowl are among the types of birds known to cause damage to agriculture around the world. Actual losses are difficult to assess because damage is usually concentrated in limited areas and, due to the mobility of birds, is often seasonal, sporadic, and hard to predict. The red-billed quelea in Africa is undoubtedly the most important bird pest species in the world.

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ABBREVIATIONS AND ACRONYMS

ADC	Animal Damage Control
AELGA	Africa Emergency Locust and Grasshopper Assistance (AELGA) Project
APHIS	Animal and Plant Health Inspection Service
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BGSU	Bowling Green State University
BRRI	Bangladesh Rice Research Institute
CGIAR	Consultative Group on International Agricultural Research
CICP	Consortium for International Crop Protection
CIMMYT	International Maize and Wheat Improvement Center (Mexico)
CPS	Crop Protection Service
CRSP	Collaborative Research Support Program
CSU	Colorado State University (Fort Collins, Colorado)
DAE	Department of Agricultural Extension
DDVP	Dichlorvos
DLCO-EA	Desert Locust Control Organization for East Africa
DWRC	Denver Wildlife Research Center
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organization of the United Nations
FEWS	Famine Early Warning System Project
FWS	Fish and Wildlife Service
GOB	Government of Bangladesh
GOM	Government of Morocco
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics (India)
INTA	National Institute of Agricultural Technology (Argentina)
IPM	Integrated Pest Management
IPRS	International Programs Research Section
IRRI	International Rice Research Institute
ISPU	International and Special Programs Unit (new name for IPRS under DWRC reorganization effective May 2, 1993)
MOA	Ministry of Agriculture
NARC	National Agricultural Research Centre (Islamabad)
NDVI	Normalized Difference Vegetation Index
NOAA	National Oceanic and Atmospheric Administration
PACR	Project Assistance Completion Report
PASA	Participating Agency Service Agreement
RCRP	Rodent Control Research Project (Chad)
RENARM	Regional Environmental and Natural Resources Management
S&T	Science and Technology
SETAC	Society of Environmental Toxicology and Chemistry
TDY	Temporary Duty Assignments
USAID	U.S. Agency for International Development
USDA	U.S. Department of Agriculture
USDI	U.S. Department of the Interior
USU	Utah State University (Logan, Utah)
VPCL	Vertebrate Pest Control Laboratory
VPM	Vertebrate Pest Management
VPS	Vertebrate Pest Section

VERTEBRATE DAMAGE CONTROL RESEARCH IN AGRICULTURE

PREFACE

Increasing food production is one of the most important challenges facing mankind. In some developing countries, the disparity between available food and population is both widespread and acute, despite the fact that about one-half of the world's population is actively engaged in agriculture. Millions of people in scores of nations still suffer hunger, malnutrition, and starvation. The reasons are many and complex, but certainly vertebrate pests (primarily rodents and birds) are important factors. Damage is unquestionably calculated in hundreds of millions and perhaps billions of dollars annually. Recognizing this, the U.S. Agency for International Development (USAID) has supported a vertebrate pest research and management project within the International Programs Research Section (IPRS) at DWRC since 1967 under Participating Agency Service Agreements (PASA's), as provided for in Section 632B of the Foreign Assistance Act of 1961 (as amended).

The cooperative program was first established between the Administrator, USAID, and the Secretary of the Interior delegating the U.S. Department of the Interior (USDI)/Fish and Wildlife Service (FWS) to conduct studies to reduce food losses caused by rats, bats, and noxious birds on a worldwide basis. This cooperative agreement was continued with the U.S. Department of Agriculture (USDA)/Animal and Plant Health Inspection Service (APHIS) with the transfer of Animal Damage Control (ADC) from USDI to USDA on December 19, 1985. Funds were provided to APHIS/DWRC by USAID missions and the USAID/Bureau of Science and Technology (S&T) to maintain a core group of international vertebrate pest specialists in the DWRC/IPRS[1] to implement the cooperative agreements.

The program goal is to evaluate vertebrate pest situations and, when circumstances warrant, develop environmentally acceptable methods to reduce their damage. Goals are accomplished by in-country programs, temporary duty (TDY) activities from the DWRC, supervisory and administrative functions from the DWRC, and problem-oriented research and training using expertise available at the DWRC. The program has been comprised of a DWRC-based outreach project and field station projects in Bangladesh, Chad, and Morocco.

The DWRC-based staff (1) coordinate overall programs, (2) respond to USAID mission requests for problem definition studies and management research, (3) represent the program to other organizations, (4) coordinate DWRC-based training for USAID-funded participants, (5) brief visitors to DWRC, (6) develop cooperative programs with international organizations and research institutions, (7) provide technical information to USAID missions or other cooperators, and (8) assist USAID personnel in program development.

[1] On May 2, 1993, the IPRS became the International and Special Programs Unit; but since most of this report covers the period prior to DWRC's reorganization, IPRS will be used throughout the remainder of this report.

The DWRC field station projects (1) establish the technical capabilities and support within governments and the agricultural sector to conduct programs in vertebrate pest research and management, (2) develop new and adapt existing practical, low-cost, and environmentally sound methods and technology to evaluate and reduce preharvest and postharvest crop losses to vertebrate pests of significant regional importance under local conditions, (3) provide onsite training in research and management methods to reduce losses by vertebrate pests, and (4) help ensure the institutionalization of a vertebrate pest management (VPM) capability in the host country.

For many years, DWRC has been recognized as a leading organization in researching vertebrate pest damage problems and developing useful tools for VPM. Its problem-solving team approach has led to developing and using new methods, materials,[2] and techniques for vertebrate pest control, resulting in monetary savings in many developing countries. The ultimate aim of this pest management research program is to develop safe, effective, and economical control methods which are suitable and practical for traditional farmers and acceptable in the broader context of agricultural development. Self-sustaining, in-country programs are the expected result of this project. Vertebrate damage problems in Africa, Asia, and Latin America are continuously reviewed with the aim of adapting current techniques or materials to specific problem situations in a crop protection-oriented management program which will provide an effective means of long-term crop protection.

The project incorporates a flexible program of applied research, technology transfer, and training. Research activities incorporate laboratory investigations at DWRC and selected laboratories in developing countries with associated field trials at appropriate sites in specific problem areas. A team approach, using the services of an interdisciplinary group of scientists and technicians with diverse backgrounds and experience, coupled with active involvement of foreign investigators, results in practical solutions suited to local requirements. In addition, it creates a professional network for continuing cooperation with indigenous institutions. Training of local counterparts and institutionalization of both research functions and implementation programs are viewed as integral parts of the overall project.

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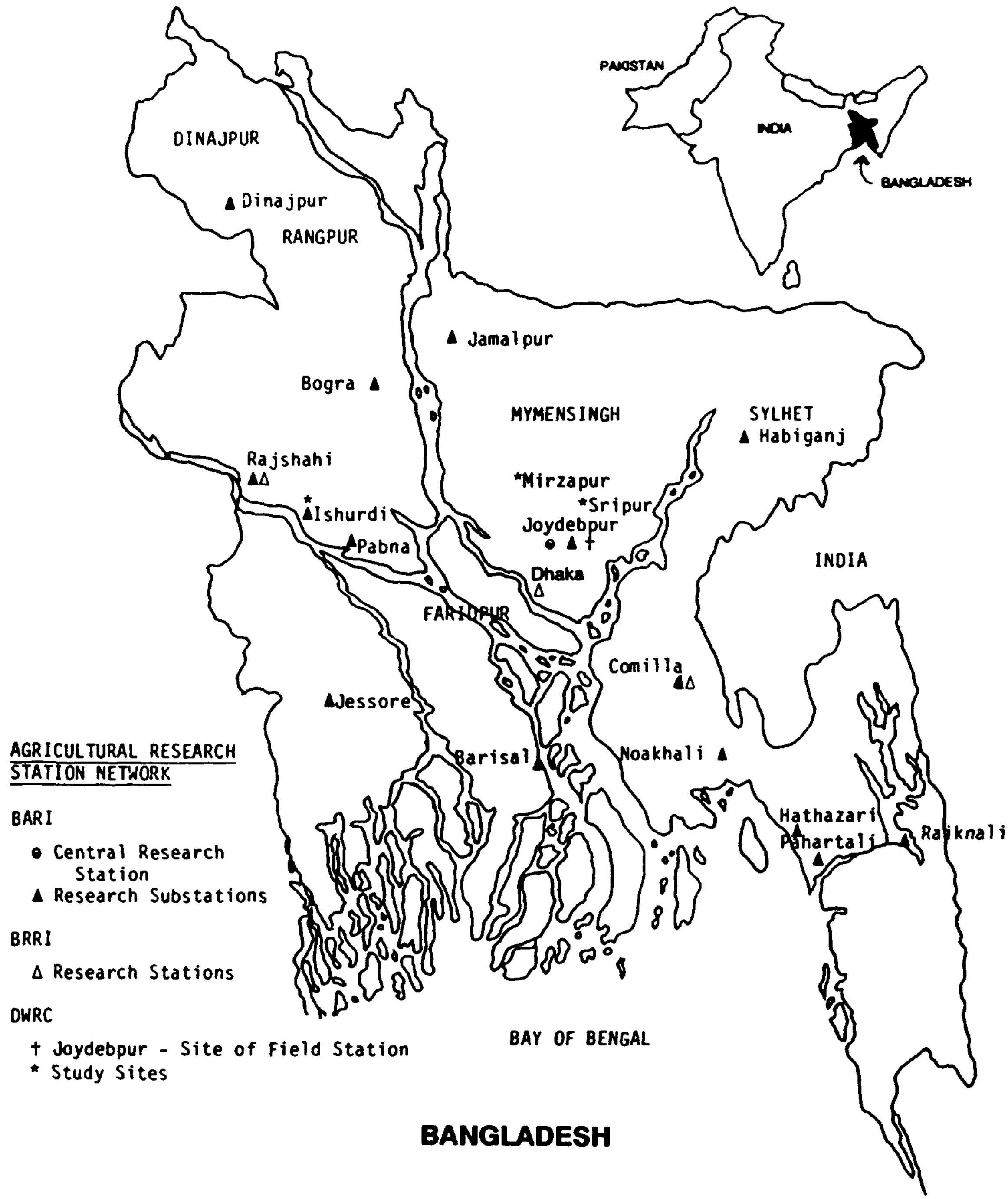
[2] Throughout the report, reference to trade names does not imply endorsement by the U.S. Government or cooperating foreign agencies.



PAKISTAN
INDIA
BANGLADESH
DINAJPUR
Dinajpur
RANGPUR
Jamalpur
Bogra
MYMENSINGH
SYLHET
Habiganj
Rajshahi
Mirzapur
Sripur
Ishurdi
Joydebpur
Pabna
Dhaka
INDIA
FARIDPUR
Comilla
Jessore
Barisal
Noakhali
Hathazari
Pahartali
BAY OF BENGAL
AGRICULTURAL RESEARCH STATION NETWORK
BARI
● Central Research Station
▲ Research Substations
BRRI
Δ Research Stations
DWRC
† Joydebpur - Site of Field Station
* Study Sites

BANGLADESH

BANGLADESH

Introduction

The vertebrate pest control program in Bangladesh was instituted in December 1978. A Vertebrate Pest Section (VPS) was established within the Entomology Division of the Bangladesh Agricultural Research Institute (BARI) at Joydebpur, 32 km north of Dhaka. The VPS was assisted in its research, technology development, strategic planning, technology transfer, and training by the USDA/DWRC through a PASA between the USDA and USAID. From the beginning, USAID/DWRC activities involved assisting in organizing the VPS, purchasing commodities, developing the laboratory, and implementing research activities. A combination laboratory-office building was completed in July 1979; several outdoor animal facilities have since been added.

The DWRC provided technical assistance in the form of three successive resident wildlife biologist project leaders, Mr. Richard M. Poché (1978-1980), Mr. Joe E. Brooks (1981-1985), and Dr. Michael M. Jaeger (1986-1990), and 46 short-term consultants from 1976 until the close of the project in 1993. DWRC also assisted in the procurement of equipment, supplies, and library resources and in conducting chemical analyses, radiotelemetry studies, and training of counterpart scientists.

The project has established and is maintaining cooperative ties with the Bangladesh Rice Research Institute (BRRI), the Ministry of Agriculture (MOA), Department of Agricultural Extension (DAE), and other organizations. Backstop support and technical assistance in various aspects of laboratory and field studies have been provided by the DWRC. The VPS is now developing practical control techniques and strategies, and staff are now working with extension personnel throughout the country to implement these strategies.

Objectives

1. Increase the available food supply.

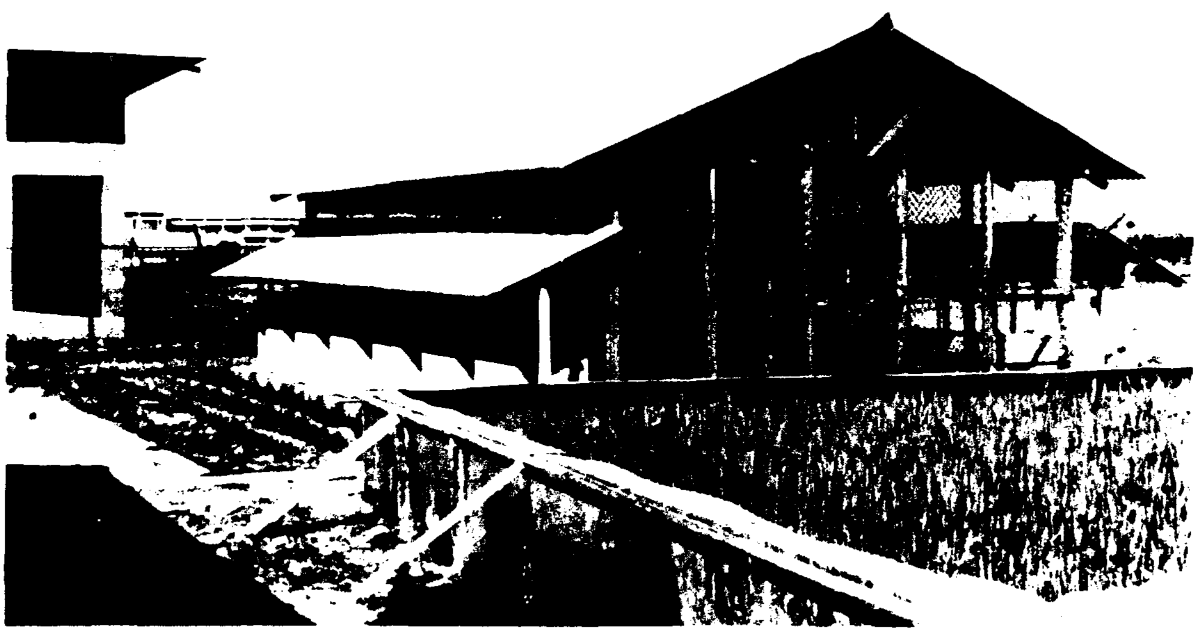
2. Develop management strategies for important agricultural situations and household stored food.

3. Appraise the nature and magnitude of losses caused primarily by rodents and jackals, and develop (if appropriate) environmentally responsible methods to reduce these losses.

4. Coordinate activities with other organizations to maximize results.

5. Institutionalize in-country research and management programs.

The Vertebrate Pest Control Laboratory (VPCL) at the Bangladesh Agricultural Research Institute (BARI) was constructed in 1979 with the goal of providing objective scientific information for developing strategies to reduce vertebrate pest damage.



The VPCL/BARI has several outdoor facilities, including pens to hold jackals, an enclosure for behavioral studies or toxicant evaluation for rodents, and an aviary for birds.

The ultimate project goal was to institutionalize a VPM research capacity in Bangladesh. To this purpose, the project has succeeded: four of the five counterpart scientists presently working with the VPS have received advanced degrees, and the VPS has become a recognized research section in BARI. Between 1978 and 1993, the VPS produced 37 technical reports and 50 published papers. Six of these scientific manuscripts are still in preparation. Also, a training manual on VPM in Bangladesh is being completed, which summarizes project findings and is geared for agricultural extension personnel.

Stages in Research and Problem-solving

DWRC vertebrate pest research and management projects normally go through several stages in trying to resolve vertebrate problems and reach their goals. While these are in logical order, progress may be simultaneous on several stages, which Dr. Jaeger outlined for the Bangladesh project:

(1) Problem definition in terms of the losses incurred, pest species responsible, and areas of the country where damage is most severe.

(2) Determination and development of control techniques most appropriate and environmentally sound under the conditions existing locally.

(3) Determination of a control strategy for when, where, and how to employ most cost-effectively the control techniques under local conditions.

(4) Implementation and transfer of the technology/strategy by assuring farmer acceptability, effective extension, and availability of quality-controlled products in local markets.

VPS Work Plan, 1978-1985

The approved VPS work plan called for conducting initial pest definition studies of jackals and rodents, evaluating rodent damage in wheat, and assessing the impact of rodents in stored food commodities at the farm and village level. Second priority was assessing the problem of pest birds in sprouting wheat and jackal damage to sugarcane, maize, and poultry.

The initial pest definition studies identified rodent damage in wheat as a major problem. Consequently, subsequent basic vertebrate research conducted by VPS under DWRC technical leadership and support focused on developing a rodent management technology for wheat. Also, part of this emphasis was because research on wheat was a BARI mandate, while research on rice came under BRRI. This basic research was planned to complement the efforts of two other donors in vertebrate pest management: the Gesellschaft für Technische Zusammenarbeit (GTZ) and the Food and Agriculture Organization (FAO) of the United Nations. GTZ support to the BARC was focused on developing extension capabilities in pest management in DAE. There was also an FAO project concentrating on

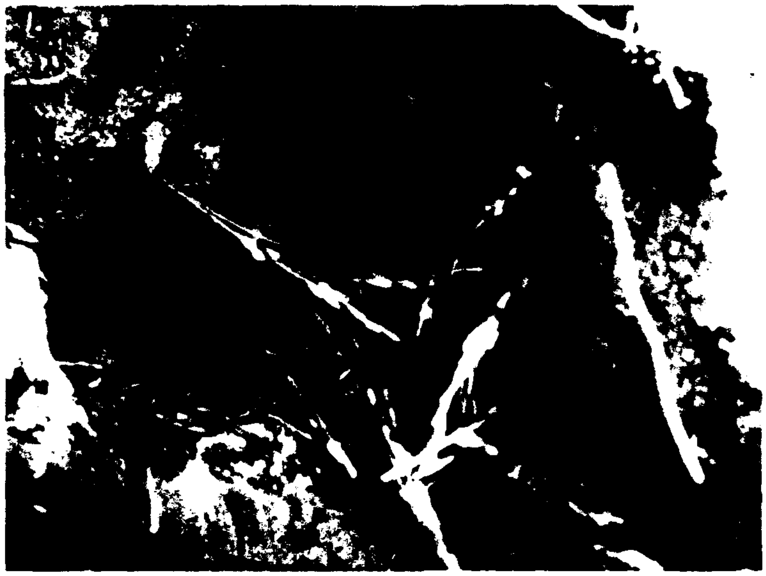
the socioeconomic aspects of postharvest food loss reduction. The VPS cooperated with these projects up until 1984 (GTZ) and 1985 (FAO), when they were terminated; after which, only the USAID/DWRC-supported project remained to continue the VPM research.

In 1981, DWRC and VPS scientists began implementing applied field research to test the economic feasibility and farmer acceptability of a particular rodent control (baiting) method in wheat. The scientists worked with the private sector to make and distribute zinc phosphide baits, and they relied on the GTZ/DAE to implement and assess the impact of the control effort. These cooperative efforts between VPS and the GTZ/DAE resulted in two countrywide rodent control campaigns in wheat during 1983 and 1984. During these campaigns, farmers using 2% zinc phosphide bait cakes received a benefit:cost ratio of 18:1 in wheat savings.

VPS Work Plan, 1985-1990

During 1985, the work plan was revised with a new emphasis on rodent control in T. aman rice, the major cereal grain grown in the country. The revised work plan emphasized the research priorities of preharvest rodent damage to rice, the importance of postharvest food losses to rodents in farm households, and the need for an in-depth analysis of jackals as pests in sugarcane and as predators on poultry. The work plan called for a systematic and objective analysis of the interactions of these three pest situations for 2 years, followed by a field evaluation of possible control methods for 1 to 2 years.

The research resulted in the development of a strategy for control of rodents in T. aman rice. Rodent numbers fluctuate annually due to predictable factors such as cropping patterns, rainfall, flood level, and length of daylight. It was postulated that annual control would be necessary and most cost-effective if focused on reducing rodent damage in aman rice during September and October before flowering occurred and when the numbers of the lesser bandicoot rat (*Bandicota bengalensis*) were low. In late November and December, rodent numbers are increasing toward their annual high, which is coincident with the maturation and harvest of the aman crop. Cooperative efforts by all farmers in the area to control bandicoot numbers at this time would reduce damage to rice, substantially reduce rodent damage to the subsequent wheat (March harvest) and boro rice (May harvest) crops and, in addition, significantly reduce postharvest losses of stored aman rice. After field-testing the control strategy for cost-effectiveness and farmer acceptability in two aman rice growing areas in late 1989 and during the wheat growing season in 1990, it was found that zinc phosphide readymade baits and aluminum phosphide fumigant tablets were equally effective, but the readymade baits were more cost-effective. This strategy was implemented in the nationwide rodent control campaigns carried out in 1991 and 1992 aman rice growing seasons.



Bandicoot burrow system with stored wheat in Bangladesh.

ACCOMPLISHMENTS

Problem Definition

The vertebrate pests of agriculture in Bangladesh were identified early in the project, based upon field observations and interviews with farmers and other agriculturists. They fall into three main groups:

(1) Rodents (rats, mice, porcupines, squirrels)
(2) Birds (mynas, parakeets, crows, weavers, munias, sparrows)
(3) Carnivores (jackals, mongoose, civet cats, jungle cats)

It was determined that the lesser bandicoot rat was the major pest in wheat, with several yearly surveys indicating damage levels of 2.8 to 12%. The lesser bandicoot and the greater bandicoot rats (*B. indica*) were found to be the major pests of broadcast deepwater aman rice (B. aman). Household-infesting rodents were found to be the roof rat (*Rattus rattus*), the house mouse (*Mus musculus*), and the lesser bandicoot rat. Interviews with 1,110 farmers in 11 districts disclosed that jackals most frequently damaged sugarcane, melons, pineapple, jackfruit, and maize, and jackals consumed chickens, ducks, and goats. Birds damaged wheat at the sprouting stage, and they ruined rice, millet, maize, and sunflower at the maturation stages. The primary bird pests in sprouting wheat were common mynas (*Acridotheres tristis*) and house crows (*Corvus splendens*). The bird pests of ripening grains were the rose-ringed parakeet (*Psitticula krameri*), crows (both the house crow and the larger jungle crow, *C. macrorhynchos*), weavers, house sparrows (*Passer domesticus*), and munias. Parakeets are the primary pests in sunflower crops. A summary of the various pests follows (Table 1).

Table 1. Major and minor vertebrate pests of Bangladesh.

RODENTS		
Major Pests		
Lesser bandicoot rat	*Bandicota bengalensis*	Wheat and rice fields, houses, godowns
Greater bandicoot rat	*B. indica*	Deepwater rice, swampy areas
Roof rat	*Rattus rattus*	Houses, sugarcane fields
House mouse	*Mus musculus*	Houses, godowns
Minor Pests		
Short-tailed mole rat	*Nesokia indica*	Root crops
Striped squirrel	*Funambulus pennanti*	Coconut, rice seed beds
Malayan porcupine	*Hystrix brachyura*	Root crops, pineapple
BIRDS		
Major Pests		
Common myna	*Acridotheres tristis*	Sprouting wheat
Pied myna	*Sturnus contra*	Sprouting wheat
House crow	*Corvus splendens*	Sprouting wheat
Rose-ringed parakeet	*Psitticula krameri*	Maize, sunflower
Jungle crow	*C. macrorhynchos*	Maize, watermelon, sunflower
Baya weaver	*Ploceus philippinus*	Rice
House sparrow	*Passer domesticus*	Rice, wheat
Munias	*Lonchura striata* and *L. malacca*	Millets
CARNIVORES		
Major Pests		
Golden jackal	*Canis aureus*	Sugarcane, maize, melons, chickens
Small Indian mongoose	*Herpestes auropunctatus*	Chickens
Jungle cat	*Felis chaus*	Chickens

Damage Assessments and Crop Losses

Assessments of rodent damage to wheat, deepwater rice, T. aman rice, and postharvest stored rice (paddy) are summarized in Table 2. Losses in wheat were estimated in 1979, 1982, and during the 1983 and 1984 national rat control campaigns. Losses varied seasonally, from 2.8 to 12%. Damage to deepwater rice was assessed in the 1983 growing season and was found to be 5.7%. Transplanted aman rice losses were estimated at 1-3%, representing between 150,000 and 450,000 metric tons/year. Stored paddy losses were estimated at 50 kg/farm household per year. The significant issue here is that many of these damages or crop losses can be decreased, and more than half the losses can be prevented through timely intervention by farmers working cooperatively in their fields. Farm-stored paddy losses could also be reduced by incorporating appropriate rodent reduction measures of trapping and poisoning in farm households.

Table 2. Damage assessments and crop losses in Bangladesh as determined by the VPS/BARI.

Crop	% rodent damage	Crop losses (mt)	Losses/farm household
Wheat	2.8-12.0*	-	-
Deepwater rice	5.7	-	-
T. aman rice	1-3	150,000-450,000	-
Farm-stored paddy	-	-	50 kg

* Varies according to season.

Rodenticides

When the project began, little was known as to how the common rodenticides would affect Bangladesh rodents. Basic toxicological studies were needed for the main rodent pests--namely, the lesser bandicoot rat, greater bandicoot rat, roof rat, and short-tailed mole rat (*Nesokia indica*). Toxicity testing was completed on three acute rodenticides--zinc phosphide, benzene sulfonic acid hydrazide (DRC-4575), and bromethalin--on both sexes of the lesser bandicoot rat, and on three chronic anticoagulant rodenticides--brodifacoum, coumatetralyl, and diphacinone. Brodifacoum was the most toxic to the lesser bandicoot rat of the three chronic anticoagulant rodenticides; within 4 to 8 days, it killed all rats that fed on the poison for only 1 night. Coumatetralyl was considered of value, since it killed all rats that ate it for 2 nights. Diphacinone was found to be the least toxic of the three rodenticides, so it was not tested further. Basic field work also tested bait cake formulations of zinc phosphide. A 1-g piece of zinc phosphide was found sufficient to kill the lesser bandicoot rat overnight. When the project began, the only rodenticide registered in Bangladesh was zinc phosphide, which was sold in small packets as technical material. Many of these packets contained very little zinc phosphide: they were adulterated with charcoal or graphite, and farmers had little faith in the efficacy of the materials. Prior to this research, other rodenticides had been used indiscriminately, including some insecticides, such as chlordane and endrin. When the DWRC/VPS project finished, zinc phosphide was registered as a 2% active-ingredient bait cake, and three anticoagulant rodenticides, coumatetralyl, brodifacoum, and bromadiolone, were registered for rodent control. These materials are registered in the United States for similar use situations.

Bird Repellents

Bird damage to crops can be reduced by the use of nonlethal chemical repellents which inhibit birds from feeding on the crops. Three chemical repellents (copper oxychloride, methiocarb, and trimethacarb), one toxic fright-inducing chemical (4-aminopyridine), and a mylar tape were evaluated against rose-ringed parakeets, blue rock pigeons (*Columba livia*), house sparrows, and white-backed munias (*Lonchura striata*). Field evaluations of the three chemical repellents in sprouting wheat showed methiocarb to be the most effective, but copper oxychloride did repel birds and, because of its local availability and low cost, it was considered more appropriate. The effects of 4-aminopyridine on parakeets, house

sparrows, and munias justified further laboratory and field trials. Parakeets gave distress calls as soon as 12 minutes after dosing; but the dose required, 10 mg/kg, was lethal to all the animals tested. When 4-aminopyridine was field-tested by exposing maize cobs and spraying them with the repellent, parakeet damage was significantly reduced. Reflecting tapes proved effective in repelling parakeets from sunflower plots for up to 15 days and deterring munias from feeding on millet plots for 10 days if alternate foods were available.

Rodent Control Strategies

Four rodent control strategies were developed during the life of the project: (1) a rodent control strategy was developed for control of rodent damage in deepwater rice by treating rodent burrows on high ground and in village housing at the time of peak flood in July/August and by treating flooded rice fields by baiting on floating mats of vegetation in August/September; (2) a control strategy for reducing damage to stored paddy was developed by treating village housing in July/August when rodents are concentrated in and around structures, either using anticoagulant rodenticide baits or large amounts of snap traps; (3) a control strategy for reducing damage to wheat was evaluated, and it was concluded that treating of rodent burrows with zinc phosphide readymade baits between the tillering and booting stages was most cost-effective; and (4) finally, the control strategy of treating T. aman rice fields by all farmers cooperatively in an area during the months of September and October, prior to flowering, reduced damage in the aman rice, but also reduced damage to the subsequent wheat and boro rice crops and substantially reduced losses to the stored aman paddy crop.

Jackal Research

Jackal Predation

The diet of jackals was sampled to determine the importance of rodents. Rodent teeth and bones were found in about 60% of the 657 scats collected and were the most common prey item. About 30% of all scats had the remains of more than one rodent, with the greatest number being six. Rats occurred more frequently than mice; roof rats and lesser bandicoot rats were the common species. Roof rats predominated at Ishurdi where sugarcane was plentiful, and lesser bandicoot rats were more common at Mirzapur where rice, wheat, and pulses predominated. Feathers, mostly from chickens, were the second most common prey item, being found in 30% of the scats. Some of these may have been obtained from jackals feeding on chicken offal at refuse heaps.

It is difficult to evaluate the impact of jackals based solely on rodent numbers, as there are a variety of other predators, including mammals, birds, and reptiles. However, it is possible to make predictions on the potential impact of jackal predation on rodent damage to a particular crop in which rodents are concentrated as, e.g., ripening wheat. A simple model of how jackal predation could theoretically reduce rodent damage to wheat is presented in Figure 1. Calculations are based on a typical 1-km^2 block of land

where 15% of the area (15 ha) is cultivated in wheat. The graph with accompanying equations shows that a single jackal can destroy 103.5 rats in wheat over a 45-day period of rodent damage, from tillering to harvest, by increasing its daily intake from an average of less than 1 rat to 4 rats. By reference to the increasing concentration of rat burrow systems in wheat as the crop matures, it is clear that the impact of predation on wheat damage changes with the number of rats consumed per day and the time remaining to harvest, so that the greatest impact is between days 15 and 20. The total number of rat days saved per jackal in this model would be 1,823, representing 127.6 kg of wheat, assuming a rat destroys 70 g per day.

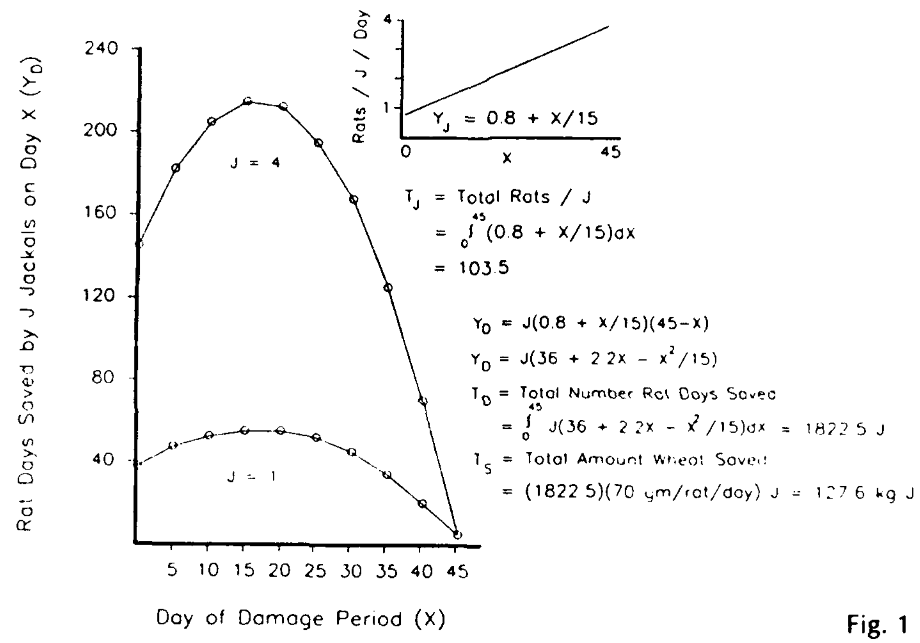


Fig. 1

Daytime Resting Cover for Jackals

The occurrence of suitable cover probably influences the distribution and number of jackals as well as other terrestrial predators in Bangladesh. Knowledge of the cover used by jackals may be beneficial to (1) understanding the factors that influence jackal mortality, (2) determining opportunities for selective control of jackals when necessary, (3) determining home range, and (4) developing a practical method for censusing.

The daytime cover and movements of 10 radio-equipped jackals (5 males and 5 females) were studied in six separate sites at Ishurdi. Seven of these animals were located in at least 5 successive months, and three were located for 11 months. Jackals were tracked in sugarcane in over 80% of the 131 observations. Sugarcane was used exclusively from December through February, and other types of cover were used after this period as the harvest of sugarcane neared completion.

Jackal Densities

Evidence suggests that jackal densities can be high. The range used for daytime cover can be an area of only about 1-2 km^2 (based on movement data for four jackals over a period of 5 to 11 months), and this area is even smaller when cover is stable, i.e., before sugarcane harvest. There are several possible implications of cover to the management of jackals in Bangladesh. First, the spatial and temporal distribution of sugarcane is probably an important determinant of local jackal densities and, as such, may be a means by which to regulate their numbers. Second, where jackals are determined to be an overall benefit, i.e., for rodent control, their numbers may be increased by the staggered presence of sugarcane. Third, where jackals are determined to be an overall detriment (e.g., where they prey on poultry and livestock), their numbers may be reduced by limiting the amount of sugarcane, synchronizing its harvest, or destroying jackals in sugarcane during the harvest when they are most concentrated.

Methods of censusing jackals by means of broadcasted howling were explored. Preliminary results indicated that the elicited response to howling is a potentially useful means of determining relative abundance and minimum densities. The use of this method seems practical and potentially valuable for providing information on the number of territorial groups in an area and on breeding success during the year. Jackal responsiveness, however, is complicated by variation between individuals and groups, and it appears to be affected by season, time of night, and moonlight.

Jackals have been reported by many Bangladesh farmers to be pests to livestock, melons, sugarcane, and corn. Jackals also consume rodents.

VPS Studies

VPS scientists have completed a number of other research studies on rat and jackal sugarcane damage assessments. Results indicated that rats and jackals damaged about 12.0% and 1.0% of sugarcane stalks, respectively, in the Sripur area of Bangladesh. Significantly more sugarcane was lost to rat damage ($\bar{x}$ = 1,288 kg/ha) than to jackal damage ($\bar{x}$ = 100 kg/ha), with respective economic losses valued at $44/ha and $3/ha. No differences were found in rat or jackal damage with respect to sugarcane varieties or proximity of cane to houses. Rats did, however, damage more of the freshly planted sugarcane than ratoon cane, and more bent stalks than standing stalks.

The VPS also completed a survey of 250 farmers at the Sripur area to estimate livestock losses to predators. Jackals (*Canis aureus*) accounted for all goat losses and 16% of adult chicken losses. Jungle cats (*Felis chaus*) accounted for 61% of all chicken losses. Crows (*Corvus* spp.) and kites (*Haliastur* spp.) killed 40% of young chickens. Also contributing to chick losses were the mongoose (*Herpestes* spp., 13%) and dog (*Canis familiaris*, 16%). Jungle cats accounted for 60% of total economic losses ($1,369), and jackals, 27% ($607). This represents $7.90 per farmer, a noteworthy amount in a country where the annual per capita income is less than $100. Chasing and beating predators with sticks was the only jackal control method reported during 1992.

Training

Five counterpart scientific officers enrolled in advanced degree training at overseas academic institutions during the course of the project—three received M.S. degrees from the University of the Philippines at Los Baños; one, a Ph.D. from Bowling Green State University; and another, a Ph.D. from Colorado State University. After acquiring his M.S. degree overseas, one counterpart enrolled in Ph.D. training at Dhaka University in Bangladesh. After 15 years, all but one of the degree recipients are still working with the project in a wide variety of laboratory and field research activities and have produced numerous technical reports and publications. The titles of their theses resulting from their advanced training are given below, along with some thesis work that was completed by other Bangladesh scientists who were not on the project but concerned in VPM research; such work also involved DWRC advisers, who critiqued and helped edit the dissertation efforts.

Md. Abdul Karim	Ph.D.	Bowling Green State University
Mrs. Parvin Sultana	Ph.D.	Colorado State University
Md. Yousuf Mian	M.S.	University of the Philippines
Md. Emdadul Haque	M.S.	University of the Philippines
" " "	Ph.D.	University of Dhaka
Mr. Rajat K. Pandit	M.S.	University of the Philippines

VPS Scientists' Theses Titles

Haque, M. E. 1982. Yield reduction in wheat by simulated rat damage. Unpublished M.S. Thesis, University of Philippines, Los Baños. 49 pp.

Haque, M. E. Biology, ecology, and control of the short-tailed mole rat, *Nesokia indica* (Gray), in Bangladesh. Unpublished Ph.D. Thesis. Dhaka University, Dhaka, Bangladesh. 143 pp.

Karim, M. A. 1983. Effects of zinc phosphide treatments on Hawaiian sugarcane rat populations. Unpublished Ph.D. Thesis, Bowling Green State University, Bowling Green, Ohio. 186 pp.

Mian, Y. 1982. Ecology and control of sympatric rodents on islands adjacent to deep-water rice in Bangladesh. Unpublished M.S. Thesis, University of the Philippines at Los Baños. 111 pp.

Pandit, R. K. 1988. Rodenticidal properties of crude extracts of *Manihot esculenta* Crantz, *Discorea hispida* Dennat., and *Thevetia peruviana* (Pers.) Merr. Unpublished M.S. Thesis, University of the Philippines at Los Baños. 55 pp.

Sultana, P. 1985. Factors affecting the performance of bird control chemicals. Unpublished Ph.D. Thesis, Colorado State University, Fort Collins, Colorado. 134 pp.

Other Cooperating Bangladesh Scientists' Theses Titles

Ahmed, S. 1981. Evaluation of rat control techniques in experimental fields of the International Rice Research Institute. Unpublished M.S. Thesis, University of the Philippines, Los Baños. 62 pp.

Ahmed, S. 1991. Development of a toxicant delivery system utilizing rodent grooming behavior. Unpublished Ph.D. Thesis, Colorado State University, Fort Collins, Colorado. 98 pp.

Sarker, S. K. (DAE) Evaluation of rodent control strategies in Bangladesh. Unpublished Ph.D. Thesis, Dhaka University, Dhaka, Bangladesh.

Three counterpart scientists received short-term nonacademic training in the United States. This consisted of specialized training given at the DWRC in Denver, one of its field stations, or Bowling Green State University, Bowling Green, Ohio.

Four counterparts participated in a 1-month course in Integrated Pest Management held at the BARI training facility during February 1985. Besides this training, the counterparts attended many seminars and workshops during the life of the project. While on TDY assignments to Bangladesh, DWRC biologists, statisticians, and computer specialists presented specialized training in various aspects of VPM research methods and techniques.

The formal degree and nonacademic specialized training have been well-focused and have provided a cadre of scientists trained at several levels in research and administrative leadership. This is an important element in institutionalizing the VPM program in Bangladesh.

DWRC Technical Assistance

Between 1978 and 1993, under USAID funding, the DWRC provided three resident wildlife biologists for 11 years, 46 short-term consultants, and technical assistance to five counterpart scientists. The short-term consultancies were by individual DWRC staff members or consultants hired by DWRC on a contractual basis; these specialists were from such organizations as Princeton University, University of Georgia, Bowling Green State University, University of California, and Idaho Department of Fish and Game. Most of these TDY's were for visits of 3 to 4 weeks or more. Eleven of these TDY's were provided to the VPS staff during the period following the departure of the DWRC resident biologist in September 1990 until the project closed in June 1993.

During the past 15 years, the DWRC also helped develop fully equipped offices, laboratories, and outdoor facilities for holding rodents, jackals, and birds on the BARI site, along with a specialized library, computers, photocopiers, and data bases for retrieval of scientific references.

Several DWRC and cooperating scientists traveled to Bangladesh between October 1992 and June 1993 to review current bird research and help plan future studies, assess technical aspects of the 1992 Rodent Control Campaign, and provide technical assistance for rodent and predator research; evaluate the various rodenticides that are available to Bangladesh farmers and assist BARI in developing a sampling scheme for monitoring the effectiveness of their National Rodent Control Campaign; make recommendations for future rodent pest management operational programs and strategies, and help establish long-term research priorities; and prepare necessary final reports that summarize project research, training, constraints, lessons learned, and recommendations for future research, cooperation, and followup evaluations.


Chad
Chad
International boundary
Préfecture boundary
National capital
Préfecture capital
Railroad
Road
0 50 100 Kilometers
0 50 100 Miles
BORKOU-ENNEDI-TIBESTI
Aozou
Bardai
Zouar
Faya Largeau
Fada
KANEM
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Bahr el Ghazal
LAC
Bol
Moussoro
BATHA
BILTINE
Biltine
Abeche
Ati
Batha
Massaguet
N'Djamena
Bokoro
Mongo
Mangalme
OUADDAÏ
CHARI-
BAGUIRMI
Massenya
GUERA
Abou Deia
Am Timan
SALAMAT
Logone
Bousso
Bongor
MAYO
KEBBI
Pala
TANDJILE
Kelo
Lai
Chari
Bahr Salamat
MOYEN-CHARI
Sarh
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Bahr Aouk
LOGONE
OCCIDENTAL
Moundou
Doba
LOGONE
ORIENTAL
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Gore

CHAD

Introduction

The Sahelian Region encompasses about 20% of Africa and includes portions of Burkina Faso, Cape Verde, Chad, Mali, Mauritania, Niger, Senegal, and Sudan. More than 30 million people inhabit the Sahel; of these, 80% are rural and directly dependent upon agriculture. The Sahel has one of the world's highest population growth rates (3-5% per annum); its population is expected to exceed 50 million people by the year 2000. The Sahel was once a major food-producing area for northern Africa, but it is now a food-deficit region due to drought, desertification, and, among other reasons, crop depredations by birds, rodents, and insects.

In 1986, several Sahelian nations declared national disasters due to massive outbreaks of rodents. USAID was hampered in providing assistance due to a lack of knowledge of the rodent species concerned, their population dynamics, and effective control measures. Short-term technical assistance was provided by the USDA/DWRC in the form of eight TDY's to the Sahel between April 1, 1987, and November 10, 1987. The crisis response was inadequate due to poor organization and lack of trained in-country personnel, materials, transportation, and time to implement needed control measures. To ensure the implementation of effective crop protection measures in the future, it was felt essential to conduct research into rodent biology and control methods; therefore, research was initiated to monitor rodent populations, evaluate control techniques, and train Ministry of Agriculture (MOA)/Crop Protection Service (CPS) personnel to effectively address future reoccurring rodent population irruptions, such as occurred in 1962, 1977, and 1986-87 in the Sahel. The Chad Rodent Control Research Project (RCRP) was initiated in 1989 as a cooperative program of the USDA/DWRC, AID/N'Djamena, and Chadian MOA/CPS. Funding was from USAID's Africa Emergency Locust and Grasshopper Assistance (AELGA) Project.

Objectives of the Rodent Control Research Project

The overall goal of the RCRP was, through research and a better understanding of the rodent pest situation, to help African countries in the Sahel achieve a greater degree of food security. The primary objectives of the work in Chad, where the project was based, included:

1. Obtain laboratory and office space, facilities, equipment, and supplies

2. Identify the major rodent pest species involved in crop depredations in the host country.

3. Determine the reproductive biology and population dynamics of major Sahelian rodent pest species through systematic rodent population monitoring.

4. Assess quantitatively rodent damage to selected Sahelian agricultural crops.

5. Develop effective, safe, economical, and acceptable methods for rodent control.

6. Provide training and/or guidelines to the MOA/CPS whereby effective long-term rodent population monitoring and control programs can be implemented.

History of the Project

Rodent surveillance/monitoring research began in October 1989. Two research sites were selected for long-term systematic studies: a recessional crop area near Karal and a dune and wadi agricultural area around N'Gouri. Field work at N'Gouri was begun during the October 1989 visits of Mr. Keith LaVoie and Dr. John Wilson. Monitoring of rodent populations was then carried out monthly by the project assistant and CPS technicians by snap trapping on transects in the N'Gouri area. Dr. Juan Spillett became in-country project leader in Chad during July 1990, and he added the Karal area as a study site in August. In December 1990, Dr. Spillett returned to the United States due to a coup d'etat in Chad; in March 1991, he resumed field work in Chad; but in December, he resigned his position. No field work was completed between December 1991 and August 1992. Between August and December 1992, DWRC provided four 1-month consultancies to Chad. DWRC also provided training at two seminars/workshops. Eighteen MOA/CPS counterpart staff were trained in rodent research and control at a 2-day Pest Management Workshop held in N'Djamena during November 1990, and 15 Chadians from the MOA and nongovernmental and private voluntary organizations participated in a 1-week seminar during September 1992. The RCRP in Chad ended in December 1992, at which time the project equipment and vehicle were turned over to the MOA/CPS for their use in continuing rodent control research work. In addition to the consultancies provided in late 1992, DWRC scientists conducted followup monitoring TDY's to Chad and Niger during September 1993.

Activities

N'Gouri Area

Rodent sampling sites were selected in late 1989 in typical wadi and dune cultivations in the N'Gouri area, approximately 230 km northeast of N'Djamena (Fig. 2). Wadi cultivation involves labor-intensive irrigation and cultivation of onions, tomatoes, peppers, okra, manioc, sorghum, and millet in scattered, small (<5 ha) oases in the interdunal depressions. Dune cultivation is extensive dryland farming of millet on dunes or sandy hills surrounding the wadis. Both cultivations are done entirely by hand.

Rodent sampling was initiated in October 1989, and trapping was done approximately monthly thereafter. One wadi site was added in June 1990 and two others in July 1990. If a wadi was not in production at the time of field sampling, it was not sampled for rodents. Animals were trapped in linear transects with 25 stations (one rat snap

trap at each station) at 10-m intervals. Six transects were set at each wadi. One transect was set in the noncultivated margin of the wadi, one transect in the noncultivated interior, another in the cultivated margin, another in the cultivated interior, and two in the noncultivated exterior. Transects exterior to the wadis differed from transects interior to the wadis by having one rat snap trap and one mouse snap trap at each of the 25 stations. Small (15-20 mm^2) pieces of cardboard impregnated with peanut oil were used for baits, following the suggestion of Dr. Wilson after his 1989 visit. Traps were set in late afternoon, left overnight, and collected the next morning.

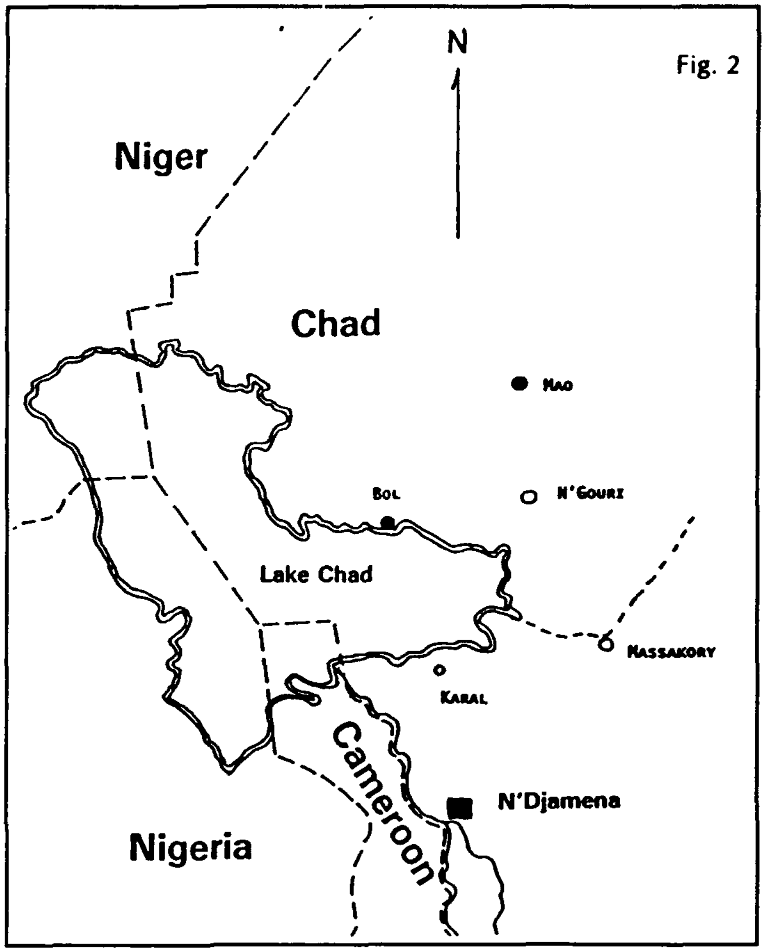


Fig. 2

Three dune sites were sampled monthly beginning in November 1989; one more dune was added in July 1990. Two linear transects of 25 stations (using one mouse snap trap and one rat snap trap at each station) were set at 10-m intervals.

Trapped rodents were identified to species, and data were recorded for sex, weight (BW), head and body length (HBL), tail length (T), age class (immature or adult), and reproductive condition of each animal. Beginning in late 1991, the hind foot (HF) and ear (E) length were recorded for each animal.

Karal Area

Rodent population sampling was initiated in August 1990 on recessional agricultural crops or in adjacent vegetative types in the Karal area, south of Lake Chad and approximately 100 km north of N'Djamena. Recessional agriculture is the planting of crops on lands that are flooded each year by the waters of Lake Chad as a result of the rainy season. As the waters recede and the lands dry, rice, corn, sorghum, millet,

cowpeas, peanuts, manioc, okra, sweet potatoes, watermelons, cantaloupe, gourds, and tomatoes are planted.

Rodent populations were sampled in a wide variety of crop types and in adjacent vegetation types with linear transects of 25 stations (one rat and one mouse snap trap at each station) spaced 10-m apart. Fields at Karal regularly were taken out of production as part of the customary farming process. Fields not in production at the time of a sampling trip were not trapped. The same data as recorded in the N'Gouri area were recorded for rodents trapped in the Karal area.

Rodent Species

Rodent pests were identified and population trends were monitored. Six rodent species were identified as important pests of dune-grown millet and winter-grown vegetables at N'Gouri and Karal: the lesser hairy-footed gerbil (*Gerbillus gerbillus*), slender gerbil (*Taterillus* sp.), robust gerbil (*Tatera robusta*), Egyptian jerboa (*Jaculus jaculus*), Nile or unstriped grass rat (*Arvicanthis niloticus*), and multimammate rat (*Mastomys [Praomys] natalensis*).

Skins and skulls of gerbil specimens (*Gerbillus* and *Taterillus*) were collected in Chad and compared with specimens at the Smithsonian Institution's National Museum of Natural History, Washington, D.C. The taxonomy presented for *Gerbillus* by Schlitter (1976) and for *Taterillus* from Robbins (1977) was followed. The *Gerbillus* specimens were identified as the lesser hairy-footed gerbil (*G. gerbillus*), based on comparisons with material collected in northeastern Nigeria, Niger, and Chad. Happold (1987) refers to the Nigerian *Gerbillus* as *G. agag*, although Rosevear (1969) places *agag* as a subspecies of *G. gerbillus*. Earlier reports of the Chad RCRP incorrectly referred to *G. gerbillus* as Anderson's gerbil (*G. andersoni*).

The *Taterillus* was not identified to species due to the paucity of Chadian specimens. It appears that three species of *Taterillus* (*lacustris*, *arenarius*, and *gracilis*) may be expected to occur in the Lake Chad area. Only the collection and comparison of additional Chadian specimens can resolve the question of species' identity. The robust gerbil (*T. robusta*) follows the description and name as suggested by Kingdon (1974).

Lesser Hairy-footed Gerbil (*Gerbillus gerbillus*)

The lesser hairy-footed gerbil is small (15 to 34 g), with sandy dorsal pelage and a pure white ventral pelage (Fig. 3). The sandy color extends in a broad stripe down to the tip of the nose. This gerbil's eyes are large and surrounded by white. A white patch occurs behind the ear. Its tail is long, sandy above, white below, with an elongated tuft of long hairs, often with blackish tips at the end. The soles of the hind feet are covered with short white hairs.

These gerbils typically live on sandy dunes, where they construct burrows to escape the daytime high temperatures. They are entirely nocturnal. They feed on grass seeds,

grass stems and roots, and insects. They are found at both the N'Gouri and Karal areas.

Slender Gerbil (*Taterillus* sp.)

The slender gerbil is medium-sized, ranging in weight from 30 to 68 g. Its dorsal pelage is sandy-orange, and its ventral pelage is pure white (Fig. 4). There is a sharp line of demarcation between the white and sandy colors. The hands and feet of the slender gerbil are white, its head is slender with a slightly pointed nose as compared with the robust gerbil, its eyes are particularly large, and the tail is usually well-tufted and darkest near the tip. The soles of the hind feet are sometimes partially haired and pigmented, as in the robust gerbil, and the upper incisors are grooved. Externally, this genus is similar to, but usually smaller than, the robust gerbil.

Slender gerbils live in burrows which are about 50 cm deep, situated in well-drained soils, and resemble those of robust gerbils. Near N'Gouri, slender gerbils appear in the thorny fencerows surrounding the cultivated wadis, along with robust gerbils, unstriped grass rats, and multimammate rats. Slender gerbils are strictly nocturnal. They are essentially seed-eaters, but consume some insects. These gerbils are found at both the N'Gouri and Karal areas.

Fig. 3. Lesser hairy-footed gerbil.

Fig. 4. Slender gerbil.

Robust Gerbil (*Tatera robusta*)

The robust gerbil is large, heavily built, and weighs between 80 to 120 g (Fig. 5). This gerbil's dorsal pelage is sandy-gray to sandy-brown, the ventral pelage is white, and its tail is sparsely haired, dark above, gray-white below, with the terminal third covered with blackish hairs. Its head is rounded in shape, and it has rather large eyes. The soles of the hind feet are naked and darkly pigmented.

Robust gerbils appear on dry, sandy soils where there is a good cover of grasses or dense shrubs or in thorny fencerows around irrigated, cultivated wadis near N'Gouri. Like other gerbils, they dig deep burrows, often with many chambers and tunnels. Robust gerbils are nocturnal; their burrows are used for resting during the day, rearing the young, and storing food. Robust gerbils are mainly granivorous, but they will eat fruits, some leaves and roots, and insects. They are found at both the N'Gouri and Karal areas.

Fig. 5. Robust gerbil.

Nile Rat or Unstriped Grass Rat (*Arvicanthis niloticus*)

The unstriped grass rat is heavily built, shaggy-coated, and weighs from 115 to 160 g (Fig. 6). Its dorsal pelage is grayish-brown to dark brown, and its ventral pelage is light-brown to medium-brown with white tips. The aspect of the dorsal pelage is best described as speckled with yellow and black. The head is rounded with a blunt nasal region. The tail is dark above, paler below, and shorter than the head and body length. The tail is also covered with small hairs.

Unstriped grass rats are common in the fencerows surrounding wadis near N'Gouri and occasionally are trapped in recessional crops near Karal, Beltram, and Guité, near Lake Chad. They are localized in their distribution because of their large water requirements, needing some form of irrigation or high residual soil moisture. Their runways can be seen along the interiors of the thorny fencerows. Surface nests as well as burrows are located in thick grasses or thorny growth. They are gregarious, but the number of rats within each burrow system tends to be regulated into small groups. Unstriped grass rats are primarily diurnal, feeding and moving about from dawn until mid-morning and again from mid-afternoon until dusk. They feed mainly on the seeds, leaves, and shoots of grasses. They also attack crops, mainly grains, cassavas, sweet potatoes, tomatoes, and eggplant.

Egyptian Jerboa (*Jaculus jaculus*)

The Egyptian jerboa is medium-sized and averages about 50 to 60 g in weight. Its head and body measures from 92 to 119 mm, and its tail is from 166 to 195 mm (Fig. 7). The jerboa's head is large and rounded, and its snout is rather blunt. Its dorsal fur is long and silky, pale sandy to sandy-red in color, while the belly fur is pure white. The basal two-thirds of the tail is covered with short sandy hairs, while

the terminal third is covered with long hairs forming a brush. Jerboa hind legs are extremely long, an adaptation for hopping and leaping, while the forelegs are rather short and held close to the chest. The long tail is used as a counterbalance and rudder when leaping. Jerboas feed mainly on seeds, roots, and bulbs.

Fig. 6. Unstriped grass rat.

Fig. 7. Egyptian jerboa.

Jerboas are common around N'Gouri, but were not recorded at Karal. They are rarely captured in snap traps. While they are crossing the roads around N'Gouri on dark nights, jerboas are easily seen in the beams from vehicle headlights. Counts of jerboas in September and October 1992 showed 4 to 5 animals per kilometer of road; and in September 1993, counts were between 6 and 8 jerboas per kilometer. Jerboas occur in sandy habitats which, for most of the year, have little ground cover except for scattered shrubs. Jerboas are nocturnal, and during the day they live in burrows where they are sheltered from high temperatures.

Multimammate rat (*Mastomys [Praomys] natalensis*)

The multimammate rat is a medium-sized (60 to 110 g) animal that is easily confused with the roof rat, except for its tail, which is shorter than the head and body (Fig. 8). The dorsal fur of the multimammate rat is brownish-gray and its ventral fur is light gray. The female may have as many as 12 pairs of mammaries (ranging from 8 to 12 pairs). Its tail is naked and unicolored.

Multimammate rats are found in both the N'Gouri and Karal areas, although they were rarely trapped in the N'Gouri wadis until after the excellent rains of 1992. This rat is one of the common species found in cultivated crops near Karal; and it is known as the village rat in Beltram, Karal, and Guité, where it lives in houses and grain storage facilities.

Multimammate rats are nocturnal and basically omnivorous in food habits. In better habitats, they tend to feed as much on animal matter, particularly insects, as on vegetable matter. When their diet is restricted, they may feed exclusively on a single item, such as cassava, rice, or maize. They live in burrows in the fields, but occupy houses and stores just as easily.

Fig. 8. Multimammate rat.

Multimammate rats are capable of reaching high densities in agricultural habitats because of their high reproductive potential. This makes them formidable pests of crops. Breeding activities are strongly correlated with rainfall. A few weeks after the onset of rains, breeding begins. Multimammate rats can have litters averaging 11 young, sometimes to 12 or 13 in times of favorable nutrition.

Important Pest Species

Of the above six rodent species, the important pest species in the N'Gouri area are lesser hairy-footed gerbils on sand dunes and unstriped grass rats in wadis. The gerbils can be important predators on dune millet crops at the time of sowing, since they dig up the newly planted seeds and store them in their burrows. This means the farmers may have to replant their crops several times. An increase in the number of unstriped grass rats, following the normal seasonal breeding, multiplies damage to vegetable crops and can cause serious losses during the winter months. In the Karal area, the important pest species is the multimammate rat, which is found in abundance in the vegetable crops in the winter months; it can damage tomatoes and sweet potatoes. This species also is a pest of stored foods in villages.

In years of deficient rainfall, these species are of chronic concern to farmers, causing some replanting of millet and minor damage to irrigated winter crops. However, when rains are normal or above—especially for several years successively—these rodents respond to better nutrition by increased breeding and better survival of young. The resulting high densities can lead to massive rodent outbreaks in the Sahel, such as seen in past decades.

Species Proportions

Between October 1989 and September 1993, a total of 1,370 rodents were captured: 876 from wadis and 313 from dunes near N'Gouri and 181 from cultivated and noncultivated sites in the Karal area.

The proportions of the several species trapped from the wadis and dunes near N'Gouri are given in Figures 9 and 10. Unstriped grass rats comprised almost 52% of the wadi rodents, with the several gerbil species comprising most of the rest. Multimammate rats accounted only for 3% of the collection. The high proportion of lesser hairy-footed gerbils in the wadi collection was from trapping on the dune slopes adjacent to the wadis, where they were captured almost exclusively.

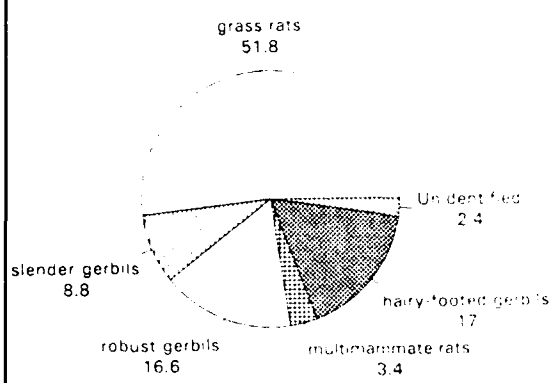


Fig. 9. Wadi rodent species.

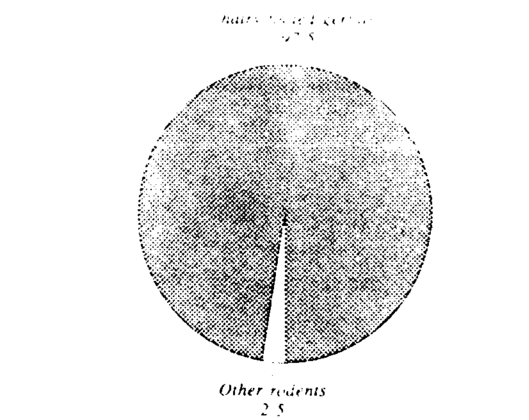


Fig. 10. Dune rodent species.

On the dunes proper, lesser hairy-footed gerbils accounted for almost 98% of rodents captured. Only three Egyptian jerboas were trapped on dunes during the 3 years of the project, although later investigations disclosed they were an important component of the dune fauna. The species proportions at Karal are given in Figure 11. All species found at N'Gouri were caught at Karal, but a *Mus* sp. was found only at Karal. Slender gerbils and multimammate rats predominated at Karal, while the *Mus* sp., robust gerbil, and lesser hairy-footed gerbils comprised most of the rest. Unstriped grass rats were rare at Karal, showing up only in the trapping during November 1992.

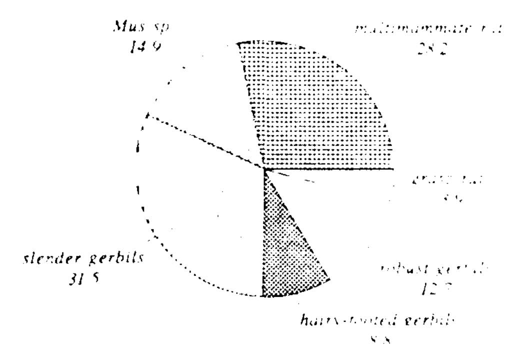


Fig. 11. Rodent species at Karal.

Rodent Breeding and Population Structure

All of the rodent species responded to the greening and maturation of weeds and grasses during and following the rainy seasons by intense breeding (Table 3). Rodent populations peaked between October and December and were dependent upon the length of the breeding season. Populations then declined until July or August when the next breeding season began. In addition, females of the unstriped grass rats and the lesser hairy-footed gerbil were found pregnant in the dry season months of February, March, and May. This may have been normal for unstriped grass rats, which lived in the fencerows surrounding irrigated crop fields and undoubtedly took advantage of this moister environment during the dry season. The gerbils bred during these dry season months in 1990, which followed only a fair rainy season in 1989.

Table 3. Breeding seasons of several Sahelian rodents from N'Gouri and Karal.

	Rainy season				Dry season							
Rodent species	J	A	S	O	N	D	J	F	M	A	M	J
Unstriped grass rat												
Multimammate rat												
Lesser hairy-footed gerbil												
Slender gerbil												
Robust gerbil												

- Months in which females were seen visibly pregnant.

The average litter sizes for several rodents for the period 1989-92 and for September 1993 are given in Table 4. The sizes of litters increased significantly for the two pest rat species in 1993. The multimammate rat and the unstriped grass rat have the largest litters.

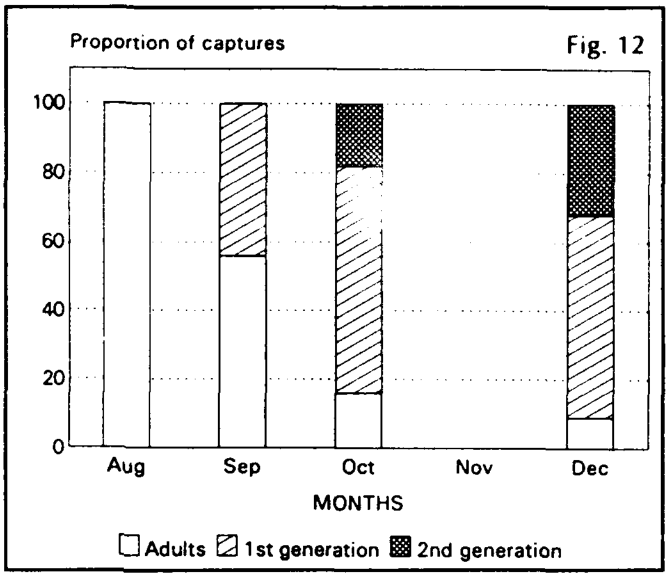
Table 4. Litter size (Mean ± SD) in several Sahelian rodents.

Species	1989-92			1993		
	No. examined	Mean ± SD	Range examined	No.	Mean ± SD	Range
Unstriped grass rat	33	6.9 ± 3.1	3-17	38	9.5 ± 2.5[a]	6-15
Multimammate rat	9	9.3 ± 4.4	4-18	8	15.3 ± 2.6[b]	12-20
Lesser hairy-footed gerbil	38	4.2 ± 1.4	2- 7	7	4.9 ± 1.6	3-7
Slender gerbil	12	5.7 ± 2.0	2- 9	8	6.3 ± 1.0	4-7
Robust gerbil	4	6.0 ± 3.6	3-11	9	5.1 ± 1.2	4-7

[a] Significantly (t = 3.91, 69 df, $P < 0.01$) greater than the mean litter size of 6.9 observed from 1989-92.
[b] Significantly (t = 3.36, 15 df, $P < 0.01$) greater than the mean litter size of 9.5 observed from 1989-92.

Immature rodents were seen in the months of September through December. In Octo' .r 1992, immatures comprised 16% of the unstriped grass rats collected, 71% of the robust gerbils, 69% of the multimammate rats, and 18% of lesser hairy-footed gerbils. Near Karal, immatures were 50% of the unstriped grass rats collected, 29% of the robust gerbils, 35% of the slender gerbils, and 50% of the multimammate rats.

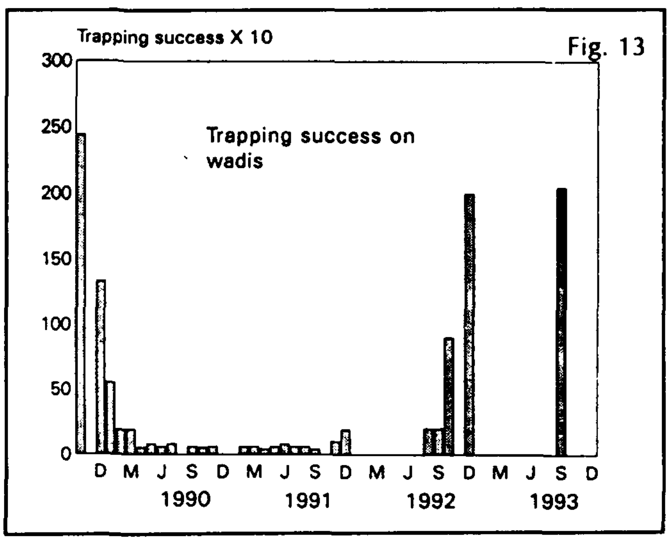
The changes in age structure of the lesser hairy-footed gerbil populations at N'Gouri from August until mid-December 1992 are shown in Figure 12. In mid-August, female gerbils were found pregnant, following the onset of the seasonal rains. In mid-September, the offspring of these dry-season survivors first appeared in Dolbeer's trapping results (Dolbeer 1992). In late October, McConnell (1992) found these first-generation animals and the dry-season survivors were breeding, and immatures of the second generation were present as 18% of the collection. By mid-December, Brooks (1992) found that 32% of the collection was second generation, while the survivors and first generation (born in August/September) were still breeding, but at a slackening pace.



These findings illustrate how rodents may respond to a season of good rainfall and excellent growth of vegetation by prolonged breeding and an outpouring of several generations within a short time. By mid-December, densities of 200 gerbils/ha were estimated based upon burrow counts on dune transects and trapping at burrows.

<u>Rodent Population Fluctuations</u>

Rodent population densities fluctuated greatly from the start of the Project in October 1989. The observed trapping success on wadis at N'Gouri for the period from October 1989 to December 1992 is given in Figure 13. From October 1989 until March 1990, trapping success progressively declined, indicating decreasing rodent populations in the wadis. By April 1990, trapping success reached its low. This trend continued for another 2 years until



the excellent rainfall of July/September 1992 when rodent populations again increased to good levels. The trapping from October/December 1992 documented rapidly increasing populations in contrast to those seen in October/December 1989 when populations were declining. Trapping success in September 1993 was exceptional, following good seasonal rains and excellent vegetation development. It was obvious that wadi and dune rodent populations were on the increase.

This same trend was seen in trapping success on dunes during the 3-year period (Fig. 14). Dune rodent populations declined abruptly from December 1989 until a low was reached in June 1990. A minor peak in trapping success was seen in March 1991, but essentially trap success remained low until August 1992 when a rapid increase in gerbils was seen on the dunes. By December 1992, gerbils were at a peak. Trapping success on the same dunes in September 1993 indicated a rapidly increasing gerbil population.

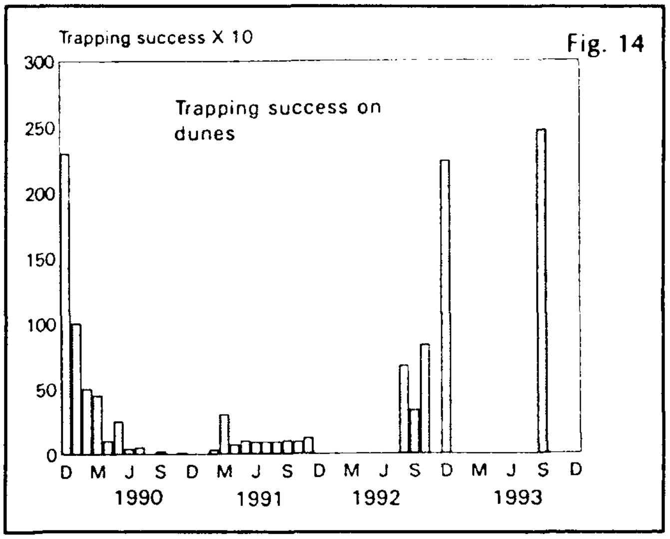


Fig. 14

Trapping at Karal was carried out basically in the period August 1990 until December 1991 (Fig. 15). Fairly good trap success was recorded in the initial months of trapping at Karal; but thereafter, except for July and December 1991, it remained low. The reasons for these low rodent population levels are discussed in the next section.

We believe that rodent populations remained at low levels throughout 1990 and 1991 because of deficient rainfall, poor timing and distribution of the rains, and a lack of green vegetative growth during this period (see discussion in next section on rainfall and Normalized Difference Vegetation Index, NDVI).

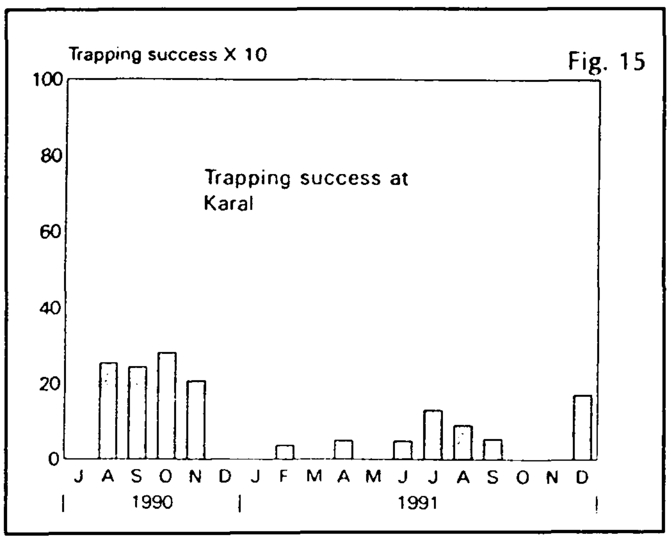


Fig. 15

Rainfall and NDVI Data

The rainfall and Normalized Difference Vegetation Index (NDVI) for N'Gouri are given in Figure 16 for each rainy season from 1985 to 1992. The data were supplied by the USAID/Famine Early Warning System (FEWS) Project in N'Djamena, Chad, and Arlington, Virginia. Data are

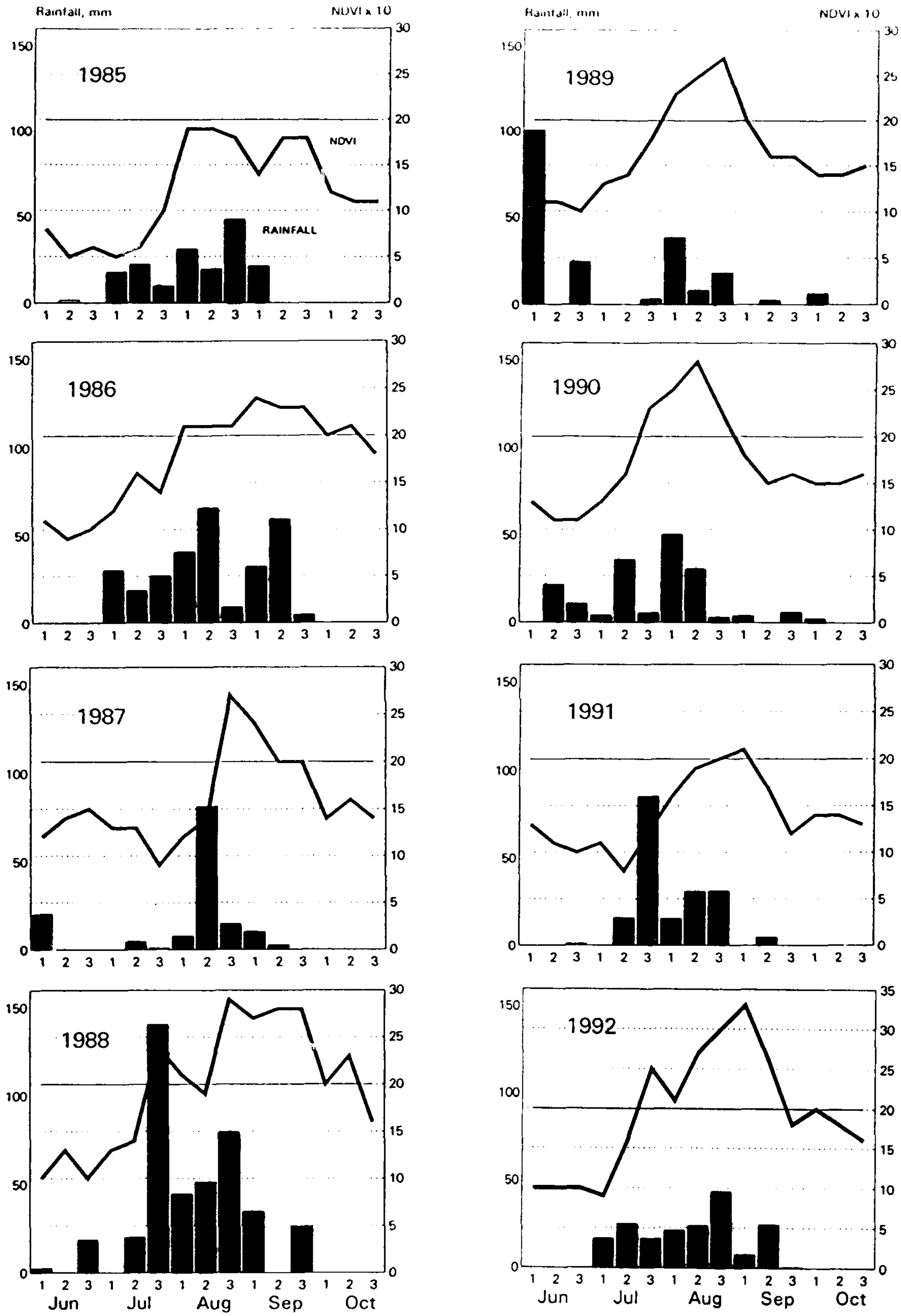


Fig. 16. Seasonal rainfall and Normalized Difference Vegetation Index (NDVI) by dekads each month for N'Gouri, Chad (data from USAID/FEWS Project).

reported in dekads by dividing the months into three 10-day periods (the final period may have 8 to 11 days, depending on the month). The NDVI images were obtained from the National Oceanic and Atmospheric Administration (NOAA) Polar Orbiting series of satellites, which remotely senses the entire Earth and its atmosphere once each day and once each night. Since chlorophyll reflects more in the infrared band than in the red band, higher NDVI values indicate the presence of more chlorophyll and, by inference, more live vegetation. A composite of daily NDVI images is created for each 10-day period, using the highest NDVI value for each pixel during this period. This minimizes the effects of clouds and other interference that tend to reduce NDVI values. NDVI is often referred to as a measure of "greenness" or "vegetative vigor."

NDVI is an index without units. NDVI ranges from -1 to 1. A value less than 0.1 indicates dry conditions. Values between 0.1 and 0.2 indicate emergence of vegetation. Values between 0.2 and 0.25 indicate generalized pastures, and a value above 0.25 indicates increasingly heavy vegetative vigor.

The rainfall amount and pattern in 1985 was not enough to result in a vigorous growth of vegetation, the NDVI never having attained 0.20 in the entire season. The patterns of rains and consequent development of vegetation in 1986 were excellent, resulting in 8 continuous dekads $\geq$0.20 NDVI. <u>This was an outbreak year for rodent populations.</u> The rainy season was weakly developed in 1987, resulting in very little development of vegetation, which was drying by the first 10 days in October. The rainfall pattern in 1988 was strongly developed and well-distributed over a 2-month period; consequently, 8 dekads scored $\geq$0.20 NDVI, but were divided into an early peak in late July and another peak from late August through late September. This probably resulted in better than normal seed production by weeds and grasses in wadis and dunes and an increase in rodent populations that was still apparent by late 1989.

The 1989 rainy season started with heavy rains in early June, but there was no apparent influence on the development of vegetation. The final rains in June did stimulate plant growth, but vegetation did not really "green up" until the first part of August. However, only 4 dekads of NDVI $\geq$0.20 were seen, and vegetation was drying back by mid-September. The pattern in 1990 was one of moderate rains spaced about a month apart until early August. The NDVI was $\geq$0.20 in only 4 dekads, and vegetation was drying by early September. In 1991, heavy rains during late July resulted in only 2 dekads $\geq$0.20 NDVI.

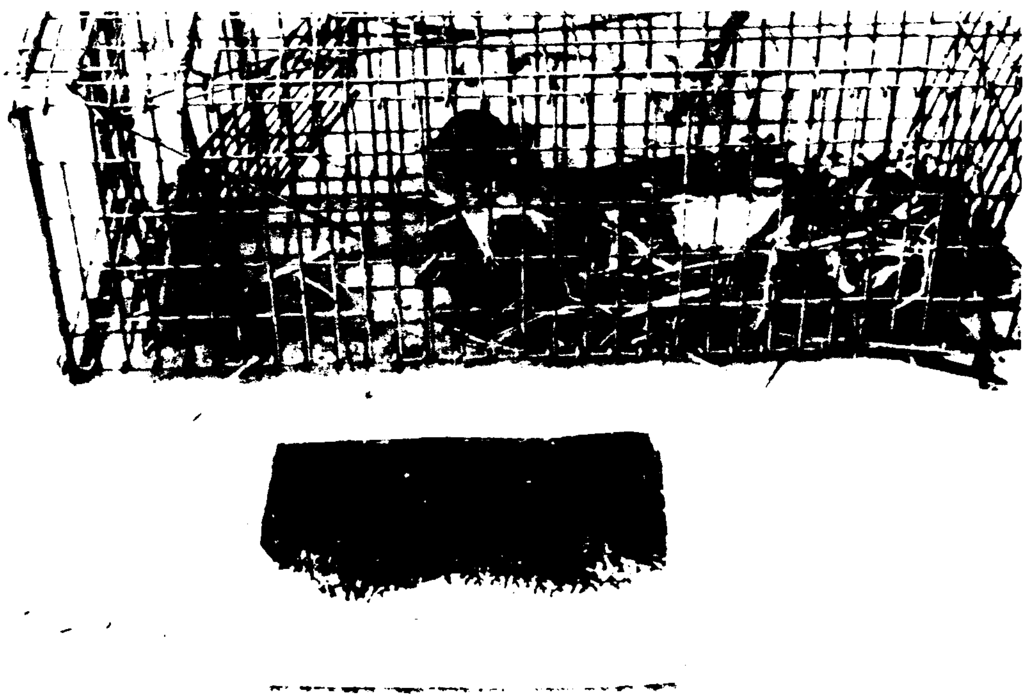
In 1992 the rains came early in July, and vegetation had greened by late July. After the vegetation dried out a little, heavy rains in August, continuing into mid-September, led to a vigorous growth of weeds, grasses, and the millet crop.

It appears that at least 6 to 8 dekads (60 to 80 days) of vegetative growth are necessary for the development of a nutritious diet and abundant seed production to which rodent populations might respond adequately. The rain patterns necessary for potential rodent outbreaks are those where vegetation has developed by the first week in August, which gives rodent populations enough time to breed for at least 4 to 5 months.

Green grasses depict conditions of the N'Gouri dunes during the rainy season in August 1992.

During the dry season, these same dunes showed signs of drought.

Pitfall traps, made from earth and water jars, were buried in the soil about 2 feet deep to catch rodents in wadis in Chad. Rodents are unable to climb out of these traps.



A tracking tile and a live trap, containing a multimammate rat, are shown. Bread had been placed in the trap as bait, but the rodent built the nest by pulling grasses into the trap.

Monitoring Methods and Comparisons

Trapping rodents with snap traps set on traplines in wadis, on dunes, and in cultivated fields in recessional agricultural areas was the method used for monitoring populations during this project. In the last months of the project, snap trapping was compared in efficacy with live trapping, tracking tiles, and food stations. Other measures of rodent activity were also used: burrow counts on transects and vehicle headlight counts of rodents crossing roads at night. It was found that for grass rats and gerbils living in wadi fencerows, live traps, tracking tiles and food stations were more effective at measuring rodent activity than were snap traps. For gerbils living on dunes, tracking tiles were twice as effective as snap traps, and food stations were five times more effective for measuring activity. Burrow count transects were used in December 1992 to estimate the density of lesser hairy-footed gerbils on dunes near N'Gouri. A count of gerbil burrows was made along a transect 4-m wide and 250-m long (= 1,000 m^2 or 0.1 ha). In December there was an average of 725 gerbil burrows/ha. Trapping at gerbil burrows revealed that 29% produced captures. This indicated there were over 200 gerbils/ha (0.29 x 725 = 210). Burrow counts of gerbils on sand dunes, combined with snap traps placed at burrow entrances, could give an excellent idea of gerbil density.

During 3 years of trapping at N'Gouri, only 3 jerboas were captured. However, during 1 night in September 1992, while taking headlight surveys on roads near N'Gouri, 5 jerboas were counted per kilometer of road, and project staff captured 10 jerboas by hand. During September 1993, road counts ranged between 6 and 8 jerboas per kilometer. Jerboas do not go to traps; consequently, using snap traps almost completely overlooks their presence.

Messrs. Trent L. McDonald and Lyman L. McDonald (1992) were able to derive a model for predicting the (square root of) trap success 2 months in advance, based on rainfall measured 2 months in the past and the current value of trap success for three cases: all rodent species combined, unstriped grass rats, and gerbils. Because no trapping and data collections were done during an actual rodent outbreak, they were unable to derive a predictive model for a rodent outbreak.

These results indicate that no one survey method is suitable for all rodents. Snap trapping is necessary for gathering data on breeding and population age structure. This method, combined with tracking tiles, would be best for grass rats, multimammate rats, and gerbils living in wadis and in fields in cultivated recessional areas. Burrow counts, combined with snap traps at burrow entrances, would be best for gerbils living on dunes. Vehicle headlight surveys would be best for jerboas and could well be suitable for all rodent species where roads pass near or through agricultural areas.

Food Preference Studies

The feeding preferences of four Sahelian rodent species for common cereal grains were investigated by the Chad RCRP counterpart staff, Maho Angaya and Djibo Koulangar, during October to mid-December 1992. Groups of three to eight rodents were offered a nightly choice between two cereal grains for 3 to 4 nights. The grain chosen most often,

along with the most consumption, was considered the preferred choice. They found the robust gerbil preferred millet and wheat was its second choice, the lesser hairy-footed gerbil preferred millet and its second choice was rice, the Egyptian jerboa preferred rice and white sorghum, and the multimammate rat preferred rice, with millet as its second choice. Previous studies by project personnel on the unstriped grass rat found this species preferred millet, with rice being its second choice. The choice of rice as a preferred food by the multimammate rat reflects its habitats, which are households, stores, and storage structures in the city of N'Djamena and in Chadian villages where rice is commonly used. Overall, millet would be the grain choice for use with toxicants against these Sahelian rodent species, with rice and wheat as good alternatives.

Toxicity Studies in Laboratory and Field

Toxicity tests were conducted in the laboratory, and baits and rodenticides were tested in the field. The toxicity of zinc phosphide, chlorophacinone, and bromadiolone was determined against multimammate rats and unstriped grass rats in the laboratory. These toxicants, used according to their labeled instructions, are registered for similar uses in the United States. When 1% zinc phosphide baits were offered to multimammate rats, 7 of 10 died. All rats eating 69 mg/kg or more died. Unstriped grass rats died by intakes of 49 mg/kg or more of zinc phosphide.

Zinc phosphide at 1% concentration was tested against rodents living in wadis and gerbils living on dunes in several field trials conducted by both Dr. Richard Dolbeer and Mr. John McConnell during their consultancies in 1992. Dr. Dolbeer recorded 79% and 95% reduction in rodent activity after 3 nights' exposure of 1% zinc phosphide in wadis near N'Gouri. Mr. McConnell used 1% zinc phosphide baits against lesser hairy-footed gerbils living on sand dunes at N'Gouri and found 15% to 73% reduction in rodent activity when baits were exposed for 3 or 4 nights. Bait (millet with peanut oil) acceptance was excellent on the dunes.

Chlorophacinone and bromadiolone at 0.005% gave complete kills of group-caged multimammate rats with 3 nights' feeding. Chlorophacinone and warfarin gave 91% and 94% reduction in rodent activity measures when used against rodents living in wadis in one trial, but results were inconclusive in another trial. The approximate 3-day LD_{50} of chlorophacinone for unstriped grass rats, based upon results from stomach gavage, was less than 0.7 mg/kg for the three doses.

Training

Training and training materials were developed for crop protection personnel, and two seminars/workshops were presented in-country. A 2-day workshop was given in November 1990 to 18 MOA personnel; this workshop included presentations on rodent identification, biology, ecology, data collection, and population monitoring. A 1-week seminar was presented in September 1992 for 15 persons from throughout Chad. A 90-page draft training manual with many visuals was specially prepared for this training, and it was

translated into French by personnel in Chad, most notably Dr. Angaya. This training manual, developed in English as well as French, was distributed to the Sahelian Ministries of Agriculture.

DWRC Technical Assistance

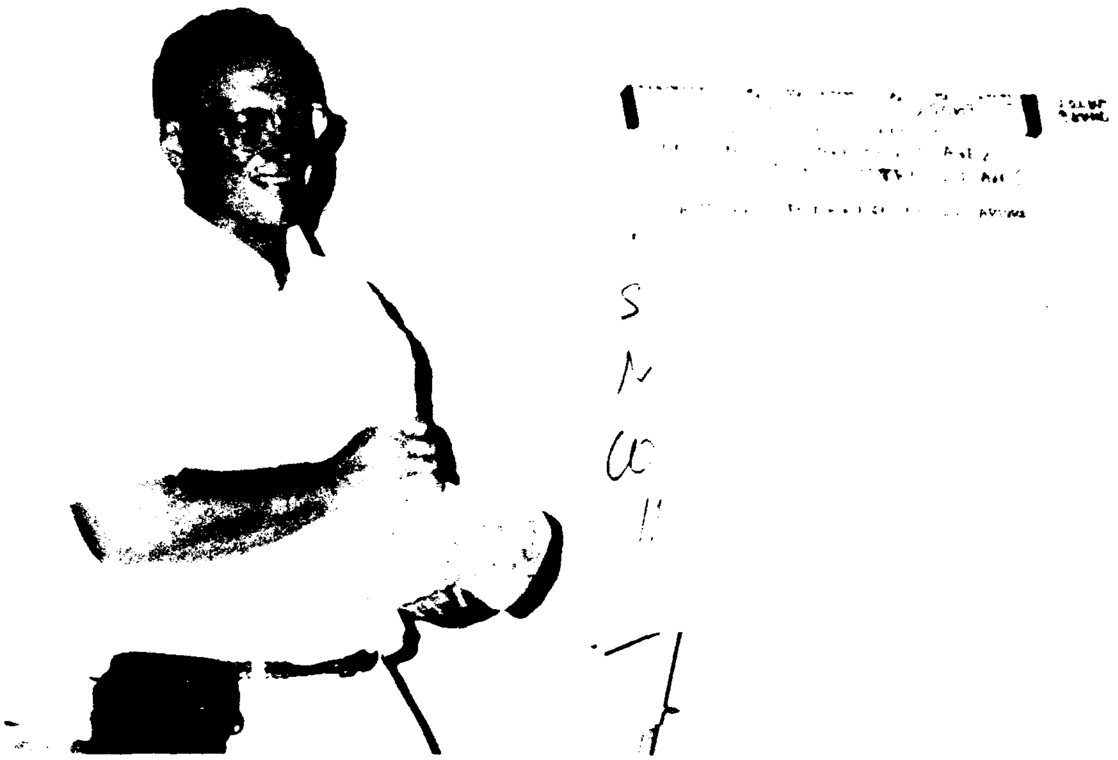
Following the resignation of Dr. Juan Spillett as in-country project leader in December 1991, no further RCRP field work was completed in Chad until August 1992. Between August and December 1992, DWRC provided four 1-month consultancies to Chad: these consultancies were completed by Mr. Joe Brooks, wildlife biologist at the DWRC/IPRS, Dr. Richard Dolbeer, wildlife biologist from DWRC's Ohio field station, and Mr. John McConnell, former in-country logistics coordinator for DWRC's Morocco Locust Control Project. Also, Dr. Dolbeer and Mr. Brooks were assisted by Dr. Maho Angaya, project assistant in presenting a rodent research and control workshop on September 8-12, 1992, to 15 Chadians.

Dr. Dolbeer again worked with the Chadian MOA between September 6 and 28, 1993, to monitor rodent populations and compare several monitoring methods; he also evaluated research and control work carried out by the CPS since December 1992. This was DWRC's last scheduled consultancy to Chad under the USAID-funded project.

During the life of the project, fourteen issues of "Rat Facts," a one-page information sheet in both English and French, were prepared and distributed; one progress report, three quarterly reports, four technical reports, and many consultancy reports were prepared; a final report was issued; and a training manual was completed in both the French and English languages and distributed within the West Africa region.

DWRC scientist points out differences in morphology among rodent pest species at the training workshop held in N'Djamena during September 1992.

Chadian participants and DWRC instructors at a 5-day rodent research and control training workshop held in N'Djamena during September 1992.



DWRC scientist uses peanuts to demonstrate marking and recapturing techniques for estimating rodent populations.

DWRC and Chadian trainers for the 5-day training workshop held during September 1992.

Dr. Maho Angaya, project assistant, illustrates different Chadian rodent species to the participants.

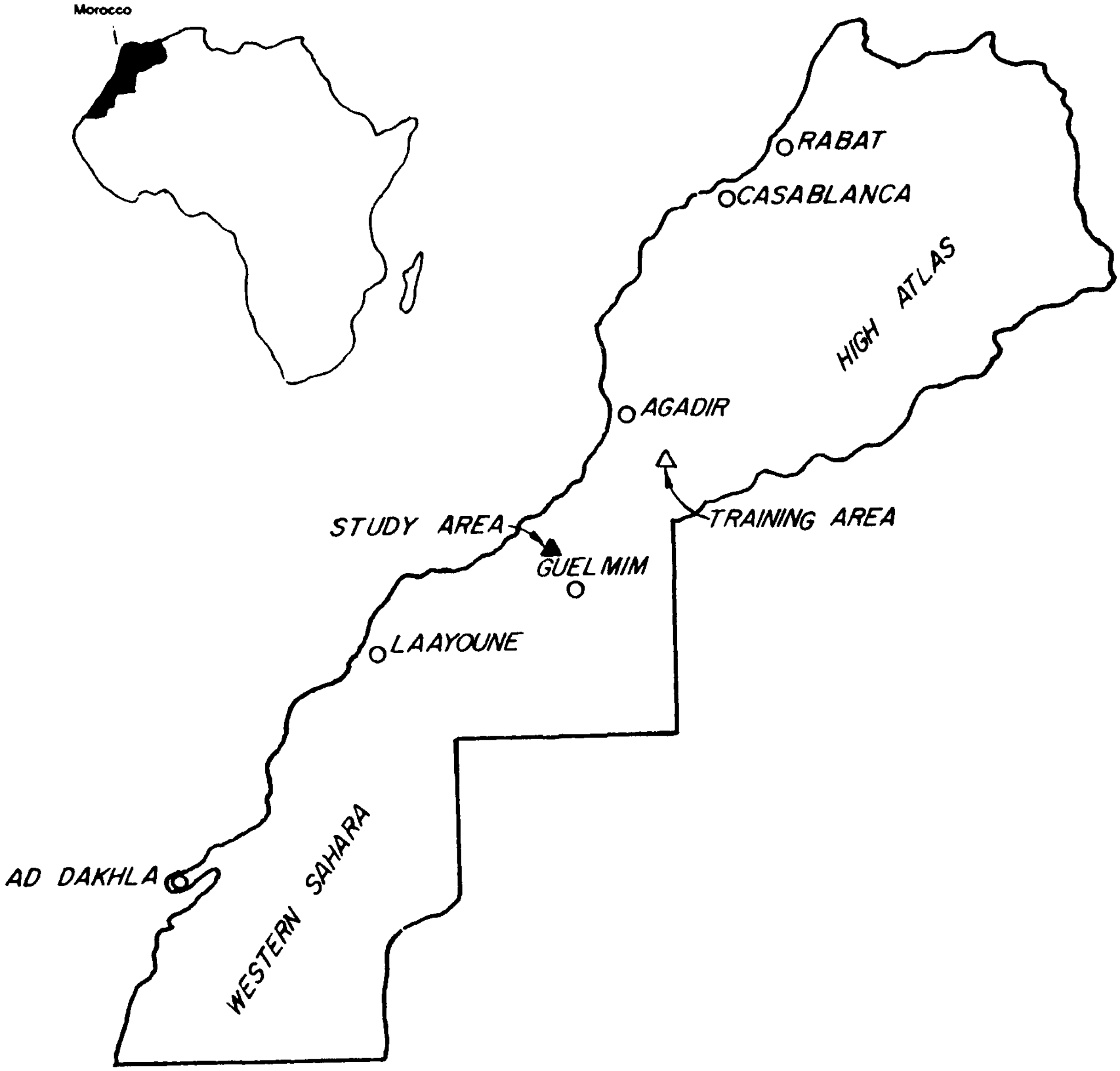
Dr. Tigaye N'Doubabe, Director of Training, Crop Protection Service, N'Djamena

During the 5-day training workshop in September 1992, Dr. N'Doubabe and Chadian participants trapped rodents in agricultural areas near N'Djamena.

The lesser hairy-footed gerbil (*Gerbillus gerbillus*) is shown outside its burrow at N'Gouri.
This gerbil is an important pest to dune millet crops at the time of sowing,
since it digs up the newly planted seeds.

Chadian counterparts setting baits in a wadi, around which thornbush had been planted to protect the crops. The thornbush in the background provides a good hiding place for rodents, while the trees behind the thornbush provide a permanent barrier to goats and sheep.

MOROCCO


Morocco
RABAT
CASABLANCA
HIGH ATLAS
AGADIR
STUDY AREA
TRAINING AREA
GUELMIM
LAAYOUNE
AD DAKHLA
WESTERN SAHARA

MOROCCO

Introduction

An irruption of desert locusts (*Schistocerca gregaria*) occurred through the African Sahel between 1986 and 1988. Affected African countries responded by initiating surveillance and control programs with the assistance of international donors. To protect agricultural crops and rangelands, Moroccans intensively used insecticides to control the locusts—between 1986 and 1990, they treated over 4.5 million ha. Most treatments consisted of using the organophosphate insecticides, malathion, dichlorvos (DDVP), fenitrothion, fenthion, and diazinon. Synthetic pyrethroids and the carbamate carbaryl were also used, but to a lesser degree. All of these materials are broad spectrum insecticides. They are capable of killing most arthropods and thereby disrupting the community ecology of invertebrates and vertebrates on treated areas. Several organophosphates are capable of causing mortality in birds. The ecotoxicological risk of pesticide use in arid regions is virtually unknown. Since most knowledge on the hazard of insecticides has been developed in more temperate climatic zones, detailed field assessments are needed to ascertain the impact of insecticides in arid regions where locust control was undertaken.

In 1989, AID/Rabat asked DWRC to conduct a two-phase cooperative project with the Government of Morocco (GOM)/Ministry of Agriculture (MOA) to (1) train Moroccan scientists in the concepts and methods of ecotoxicological studies and (2) conduct studies of the environmental effects of malathion and dichlorvos, the two principal insecticides that had been used in Morocco's locust control campaigns.

Objectives

A. Conduct a series of short training courses for Moroccan biologists on methods used in toxicological studies. Training focused on the following agenda:

1. Introduction to the history, concepts, and conduct of ecotoxicological studies

2. Chemical analysis for organophosphate insecticide residues in environmental samples

3. Cholinesterase analysis of brain tissue from animals to determine the intensity of their exposure to organophosphate insecticides

4. Radiotelemetry techniques used in determining lethal, sublethal, and behavioral effects of insecticides on wildlife

5. Field techniques for study of insecticide effects on numbers, food habits, reproduction, and behavior of birds and mammals

6. Field techniques for study of insecticide effects on selected arthropods (foods of birds and mammals, honey bees, as well as the predators and parasites of locusts and grasshoppers)

7. Training on experimental design of studies and statistical analyses of data

B. Conduct research during the rainy season (time of highest biological activity and diversity) to evaluate effects of malathion and dichlorvos applications to experimental plots on birds, mammals, and insects, and also, to assess contamination of the environment.

Specific research objectives included the following:

1. Determine the impact of locust sprays on the numbers and/or activity of birds, mammals, and beneficial insects on study plots before and after treatments.

2. Determine treatment effects on the food habits and food availability of vertebrates.

3. Determine initial level of spray deposits on plots and their persistence in soil and vegetation.

4. Determine exposure of selected vertebrate species through measurement of brain cholinesterase.

Activities

Between May 1990 and October 1991, DWRC conducted six training sessions for Moroccan participants in methods for evaluating ecotoxicological impacts, collecting animal and plant tissues for measurement of pesticide residues, measuring chemical residues, statistical techniques, radiotelemetry, and determining the relative abundance of birds, mammals, and beneficial insects in the field.

The research phase of this project, which was to evaluate the effects of field applications of malathion and dichlorvos on birds, mammals, and beneficial insects, was originally planned for February-March 1991, but had to be rescheduled for early 1992 due to travel restrictions created by the Persian Gulf crisis. Treatments were to be made to experimental plots where, most likely, locusts would not be present, but where adequate data might be obtained prior to treatments. In operational control, insecticides are usually applied onto swarms the day after the swarms are located in the field, which leaves inadequate time to collect pretreatment information.

In January and February 1992, U.S. and Moroccan scientists (Table 5) conducted studies on nine 3-km^2 experimental plots near Guelmim, Morocco, to evaluate the effects of these chemicals on birds, mammals, and insects. A helicopter sprayed three plots with malathion at rates of 750 g/ha and three with dichlorvos at rates of 200 g/ha; three plots were untreated. However, applications resulted in less than anticipated deposits of insecticides.

Table 5. Moroccan and American research teams.

Teams	Americans	Moroccans
Insects	P. Matteson	A. Baou A. El Fayq S. Ghaout A. Mouhim El Jaouani A. El Bakkouri
Bees	—	L. Abail D. Aid Belarbi L. Zerhloul S. Merzouk
Birds	R. Bruggers J. Heisterberg	A. Aloui A. El Hani H. El Addami
Mammals	R. Curnow L. Fiedler J. McConnell	H. Arroub A. Ouzaouit B. Id Messaoud
Radiotelemetry	P. Hegdal J. Bourassa R. Johnson R. Phillips	O. Alhillali M. Ramzi
Cholinesterase	J. Keith	A. Akchati M. Benchra S. Sahil
Residues	J. Gillis	M. Tarhy A. Daia A. Falaq
Searches	J. Keith	Local residents
Deposits	—	A. Afrass S. Lagnaoui
Data Entry	R. Engeman L. Fiedler R. Curnow R. Johnson	All participants

Malathion residues on vegetation were low, and residues in soil decreased 85–90% after 1 week. Only trace amounts of dichlorvos were recovered from either soil or plants. Among birds and mammals, inhibition of cholinesterase was found only in brains of thekla larks (*Galerida theklae*) on malathion plots. No apparent mortality or significant effects on numbers or activity of birds and mammals were recorded. Malathion killed bees and reduced the abundance of ants, orthopterans, and apparently one species of beetle (*Adesmia dilatata*). Dichlorvos did not affect insects as severely, but it appeared to reduce the abundance of Tenebrionid beetles and the numbers of bees entering hives. Bird and mammal food habits were not greatly affected. The percentage of animal matter eaten by red-rumped wheatears (*Oenanthe moesta*) decreased on dichlorvos plots, and ants largely disappeared

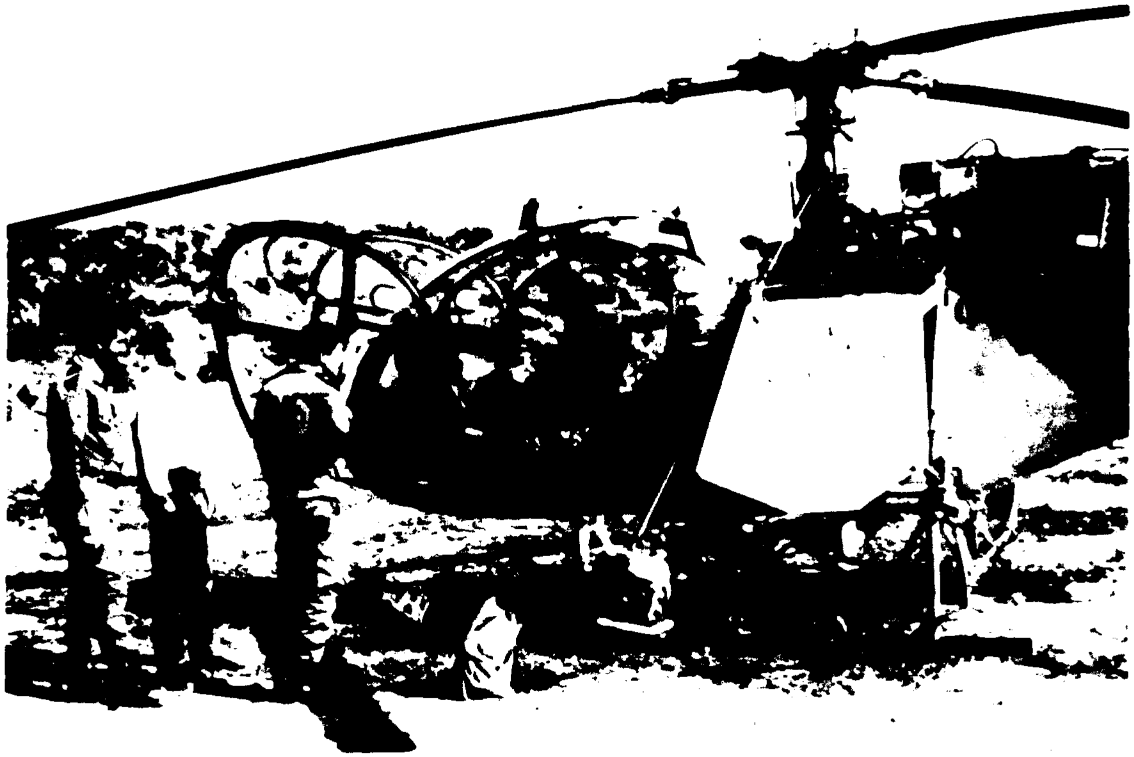
from diets of birds on malathion plots. More intense effects of both insecticides undoubtedly would have occurred if insecticides had been effectively applied to experimental plots.

Although the results obtained in this study were compromised by inadequate treatment of plots with insecticides, the ultimate purpose of this project and of the field research was to prepare Moroccan scientists to conduct future ecotoxicology studies; this was accomplished.

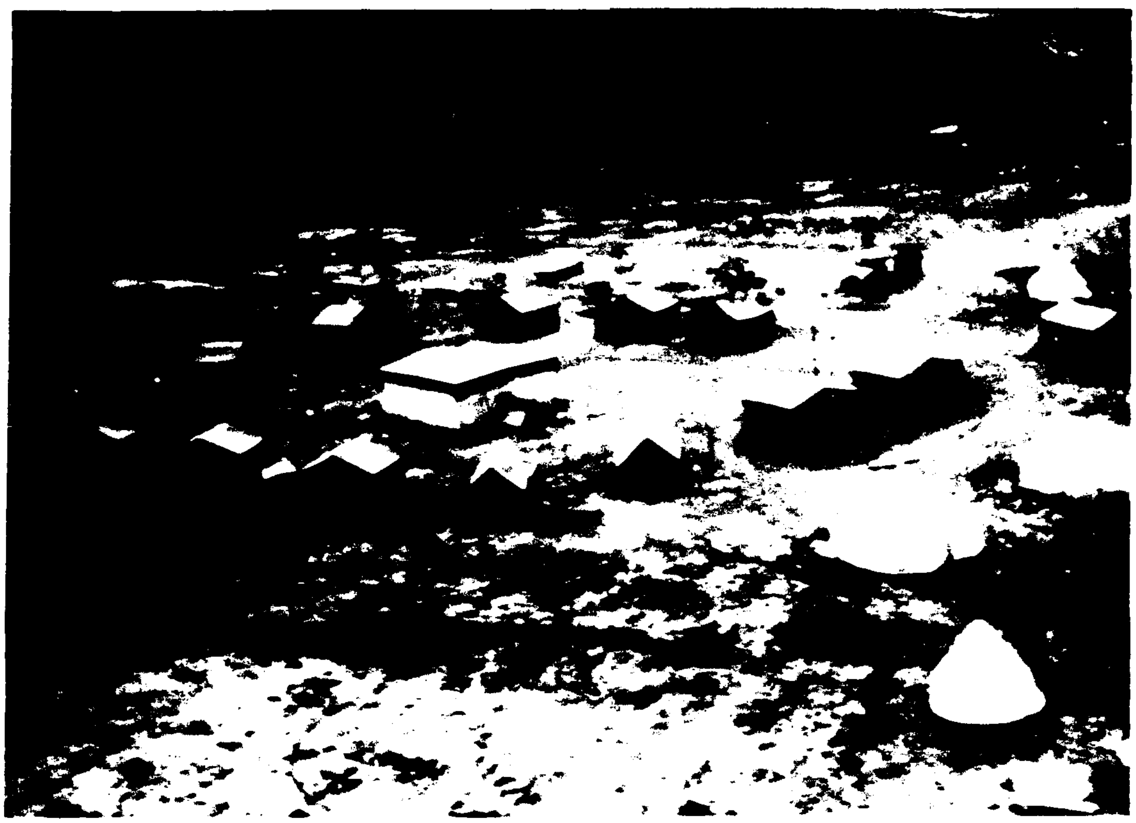
DWRC Technical Assistance

Dr. Michael Avery (DWRC's Florida field station), Dr. James Keith (study director of this Morocco Locust Control Project), and Mr. Keith LaVoie (retired)—all wildlife biologists from the DWRC, and Dr. Patricia Matteson, entomologist from Iowa State University, worked in Morocco between October 6 and 27, 1991, with 18 scientists from the Morocco MOA. During January and February 1992, nine current or former DWRC scientists, a specialist from the Environmental Protection Agency (EPA), an ornithologist from Animal Damage Control (ADC) Operations, and an entomologist from Iowa State University, traveled to Morocco to assist in the research. At one time almost 70 individuals were in camp implementing this research. Three of the Moroccans (Messrs. Said Ghaout, entomologist; Abderrahim El Hani, ornithologist; and El Hassan Arroub, mammalogist) who participated on research teams, visited the DWRC between April 26 and May 16, 1992, to work with DWRC staff in preparing the final report.

American and Moroccan research teams at study area camp site.



A Moroccan army helicopter was used to spray insecticides on the test plots.



Tent camp in southern Morocco from which locust research was conducted.

Radio-equipped little owl (*Athene noctua*) in Morocco.

A Moroccan scientist conducts bird counts.

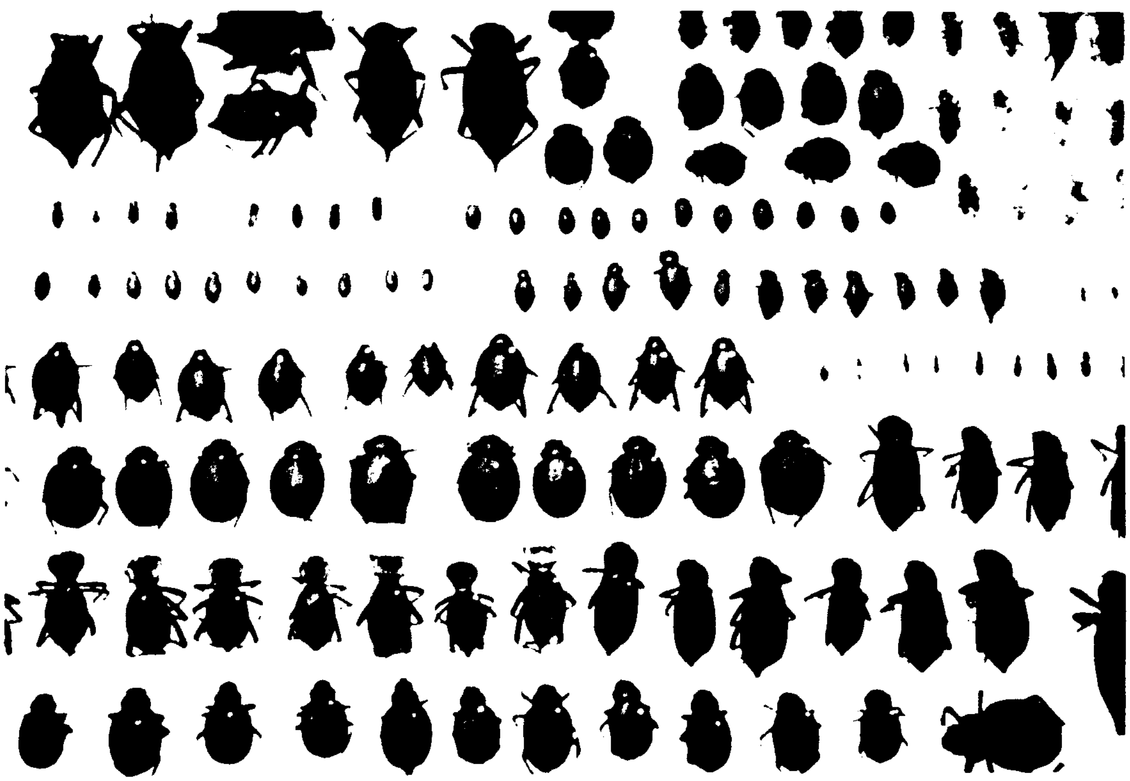
A researcher locates previously trapped radio-tagged rodents
to determine their movements and survival rate.

A DWRC scientist prepares rodent study skins.

Moroccan scientist measuring wind speed and direction at bee hives.

Moroccan and EPA chemists sampling vegetation for pesticide residues.

A Moroccan scientist samples insect abundance from the study area.



Selected examples of beetles collected from study site.

DENVER-BASED OUTREACH ACTIVITIES

Introduction

Under the 1967 cooperative program established by the Administrator, USAID, core funds were provided to DWRC by the USAID/S&T to maintain a group of international vertebrate pest specialists in the DWRC/IPRS to implement outreach activities in international VPM. The program goal has been to evaluate vertebrate pest situations in Africa, Asia, and Latin America and, when circumstances warrant, develop and implement environmentally acceptable methods to reduce vertebrate pest damage. Goals were accomplished by in-country programs, TDY activities, supervisory and administrative functions from the DWRC, and problem-oriented research and training using expertise available at the DWRC.

Objectives

1. Provide supervisory, administrative, and TDY support for foreign field stations.

2. Conduct cooperative problem-oriented research at DWRC based upon field program priorities.

3. Develop and implement proposals for VPM programs worldwide.

4. Provide scientific support, on request, to AID/Washington, USAID missions, and foreign governments by

    a. Providing TDY technical assistance to developing countries.

    b. Arranging and providing training for foreign VPM technicians, administrators, and graduate students at DWRC.

    c. Coordinating VPM participation in international workshops, symposia, and conferences.

    d. Responding to inquiries and foreign assistance requests to DWRC through correspondence, reports, publications, and cooperative research.

5. Work with international organizations, such as the Food and Agriculture Organization (FAO) of the United Nations, World Bank, Desert Locust Control Organization for East Africa (DLCO-EA), and Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) on research problems of mutual interest.

6. Perform supervisory and program development functions at DWRC.

DWRC Information Transfer

During Fiscal Years 1992 and 1993, IPRS received and responded to 207 requests from 80 countries for information, training, and technical assistance. Reprints and reports totaling 3,321 were provided to scientists and other individuals worldwide (Table 6).

Table 6. Requests to DWRC for assistance between October 1, 1991, and September 30, 1993.

Type of request or activity	Total No.
Information on International Programs	8
Information or Literature on Research and Crop Protection Methods	95
Information on Graduate Schools in VPM	6
Materials/Photographs	18
TDY's Implemented by or through IPRS in Technical Assistance Research, Training, and Extension	25
Requests of IPRS for	
- Funds	9
- Research Opportunity	7
- Training	17
- Hiring	7
- Project Development	15
No. International Visitors	45
No. Reprints Distributed	3,321
TOTAL	3,573

Originating countries and regions:

Argentina, Australia, Bangladesh, Belgium, Belize, Bhutan, Botswana, Brazil, Burkina Faso, Burundi, Cambodia, Canada, Chad, China, Colombia, Costa Rica, Côte d'Ivoire, Croatia, Denmark, Dominican Republic, Germany, Ecuador, Egypt, Ethiopia, Finland, France, Guam, Honduras, Hong Kong, Hungary, India, Indonesia, Ireland, Israel, Italy, Jamaica, Japan, Kenya, Latvia, Lebanon, Malaysia, Mali, Marshall Islands, Mexico, Morocco, Namibia, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Pakistan, Paraguay, Philippines, Poland, Portugal, Puerto Rico, Russia, Saudi Arabia, Senegal, Sierra Leone, Slovenia, Somalia, South Africa, Spain, Sri Lanka, Sudan, Sweden, Switzerland, Taiwan, Tanzania, Thailand, United Arab Emirates, United Kingdom, U.S.A., Uruguay, Venezuela, West Africa, Zambia, and Zimbabwe.

DWRC Outreach Consultancies

The DWRC has for many years implemented programs for the international donor community to increase available food supplies for subsistence farmers in developing countries by reducing losses to vertebrate pests. In May 1992, the Washington-based Population Crisis Committee published the results of its study, titled "International Human Suffering Index." This study ranked 141 countries on the basis of 10 indicators of human well being, one of which is daily food availability. Of the 15 countries ranked most in need of aid, DWRC has provided short-term assistance to 9 (Chad, Ethiopia, Guinea-Bissau, Haiti, Mozambique, Sierra Leone, Somalia, Sudan, and Uganda), and managed in-country field stations in 3 (Chad, Haiti, and Sudan). While increasing food availability is only one of many criteria necessary to reduce the level of suffering in these and other developing countries, this study shows that efforts in this area are still very much needed for many of the world's poorest countries, and that a role still exists for DWRC's expertise. However, all USAID funding to DWRC's international programs in this area has now ended, a situation that will greatly impact all future activities.

Between October 1991 and September 1993, DWRC staff traveled to Africa, Asia, South America, and Europe at the request of USAID missions, AID/Washington, FAO, foreign governments, and the USDI/FWS to assess vertebrate pest problems; to review, evaluate, and coordinate present and future research programs; to evaluate the impact on the environment and nontarget wildlife of locust control sprays; and to participate in workshops and conferences. TDY activities from DWRC have been an important part of the project, as many types of short-term evaluations and cooperative studies with host-country scientists have been carried out expeditiously in this manner. Travel during FY-92 and FY-93 involved 1,250 person-days to the following locations:

Argentina	Egypt	Mali	Portugal
Bangladesh	Guam	Malaysia	Pribilof Islands
Burkina Faso	Hong Kong	Morocco	Senegal
Canada	Indonesia	Nicaragua	Thailand
Chad	Italy	Niger	Uruguay
Costa Rica	India	Pakistan	
Côte d'Ivoire	Japan	Philippines	

Travel dates, persons involved, locations visited, and the purpose of each trip are outlined briefly in Table 7. Detailed information is contained in individual trip reports on file at DWRC/IPRS. Travel to Argentina and Uruguay was funded by FAO and through the USDA/DWRC sabbatical program. Travel to Guam, Japan, and the Pribilof Islands was funded by USDI/FWS.

Table 7. International travel for technical assistance projects by USAID/DWRC personnel between October 1991 and September 1993.

Date	Name	Location	Purpose of trip
1991			
Sep 15-Oct 9 Sep 25-Oct 4 Sep 17-Oct 3 Sep 23-27 Sep 27-30	P. J. Savarie R. L. Bruggers W. S. Wood[1] G. C. Mitchell[2] R. M. Engeman[3]	Guam	Conduct tests in a simulated nonfood cargo situation on Guam to determine the effectiveness of methyl bromide as a fumigant for control of brown tree snakes.
Sep 20-Oct 11	R. W. Bullard	Argentina and Uruguay	Complete second segment of consultancy regarding nonlethal chemical control of bird pests and assist bird control specialists in their study design. Present six lectures and participate in a training course "Curso Binacional Sobre Manejo Integrado de Aves Plaga" at Salto, Uruguay.
Sep 30-Oct 22	D. L. Otis	Argentina and Uruguay	*Evaluate the need for reliable information about the distribution and* magnitude of economic losses caused by several species of birds to agricultural crops in Uruguay and Argentina, and recommend *statistically reliable* sampling designs *for* research *and* extension programs.
Oct 6-27 Oct 12-27	J. O. Keith M. L. Avery G. K. LaVoie P. C. Matteson	Morocco	Conduct preliminary work on study area proposed for early 1992 research, and train Moroccan scientists on identification of terrestrial insects.
Oct 28-Nov 26	L. A. Fiedler	Bangladesh	Assess 1990/1991 Vertebrate Pest Control activities, including involvement in National Rodent Control Campaigns and develop cooperative research plans for 1992.
Dec 9-20	R. L. Bruggers	Argentina and Uruguay	Determine potential usefulness of different marking techniques in research on eared doves and monk parakeets in Argentina and Uruguay.

[1] Biological Scientist, Technology Support Staff, USDA/APHIS, Hyattsville, Maryland.
[2] Travel was coordinated through IPRS.
[3] Dr. Engeman traveled to Guam while on a sabbatical in Brisbane, Australia.

Table 7. Continued.

Date	Name	Location	Purpose of trip
Dec 9-20	M. M. Jaeger	Argentina and Uruguay	Test efficacy of a CPT-treated grease/gel formulation applied externally on the feathers of parakeets.
May 2, 1990, to Jun 3, 1992	J. E. McConnell	Morocco	Serve as IPRS in-country logistics coordinator for the Morocco Locust Control Project.
1992			
Jan 17-Feb 28	J. O. Keith	Morocco	Evaluate effects of field applications of malathion and dichlorvos on birds, mammals, and beneficial insects in Morocco to gain pretreatment data.
Jan 17-Feb 11	R. L. Bruggers		
Jan 17-Feb 11	R. D. Curnow		
Jan 16-Feb 9	P. Hegdal (Retired)		
Jan 17-Feb 14	J. Bourassa		
Jan 18-Feb 27	P. C. Matteson (Iowa State University)		
Jan 24-Feb 10	R. M. Engeman		
Jan 24-Feb 21	J. N. Gillis (EPA)		
Feb 2-23	J. F. Heisterberg (ADC)		
Jan 30-Feb 22	R. L. Phillips		
Jan 30-Feb 22	R. E. Johnson		
Jan 30-Feb 27	L. A. Fiedler		
Mar 11-28	J. E. Brooks	Senegal	Assess Sahelian rodent populations in Senegal and determine in-country capability to set up rodent monitoring sites for possible regional networking.
Mar 17-Apr 13	L. A. Fiedler	Niger, Burkina Faso, Mali, and Côte d'Ivoire	Assess rodent control programs and problems in Niger, Burkina Faso, Mali, and Côte d'Ivoire; and determine the feasibility of establishing rodent population monitoring sites and a regional rodent monitoring network that would provide an early warning of impending rodent outbreaks.
Mar 28-Apr 11	R. L. Bruggers	Bangladesh	Discuss past and future research, extension, temporary duty assignments, budgets, training, and general project implementation until June 1993.

Table 7. Continued.

Date	Name	Location	Purpose of trip
1992			
Apr 9-29	D. Saltz	Bangladesh	Review study design and provide statistical and computer assistance to the VSP/BARI.
Apr 14-May 16	C. E. Harris	Bangladesh	Review 1991-1992 predator research on jackals in Bangladesh, and provide advice on other studies and future research.
May 2-Jun 5	E. Brooks	Pakistan, Bangladesh, and India	In Pakistan, evaluate current and future research, training, and technology transfer programs of the Vertebrate Pest Control Laboratory/NARC. In Bangladesh, evaluate the 1991 National Rat Control Campaign and recommend improvements, and survey the quality, availability, and cost of rodenticides; discuss cooperative research possibilities. In India, explore the possibility of cooperative research.
Jun 16-Jul 15	J. J. Jackson	Bangladesh	Strengthen extension efforts in rodent control in aman (monsoon season) rice production; help prepare training materials, evaluate rodent control campaign effectiveness and use of the media, and design a more effective rodent control campaign evaluation scheme.
Aug 9-Sep 13	J. E. Brooks	Chad	Handle DWRC project administrative and fiscal details with AID/N'Djamena, conduct field work, and prepare and present training workshop and laboratory toxicity studies.
Aug 26-Sep 27	R. A. Dolbeer	Chad	Assist in planning and presenting a 5-day training workshop, conduct field rodenticide trials, and continue collecting data on Sahelian rodent populations.
Aug 26-Sep 29	L. A. Fiedler W. B. Jackson	Philippines, Indonesia, Thailand, Malaysia, Hong Kong, and India	Identify and describe the current status of vertebrate pest management research and training activities in selected Asian countries and institutes, and determine current and future needs; recommend strategies for incorporating appropriate effective integrated rodent pest management technologies.

Table 7. Continued.

Date	Name	Location	Purpose of trip
Sep 16-Oct 1	P. J. Savarie	Guam and Japan	Attend USDI Activities Meeting for the Department of Defense Legacy Demonstration Project and assist USFWS research personnel in initiating a brown tree snake field study on Guam; present paper on "Candidate repellents, oral and dermal toxicants, and fumigants for brown tree snakes" at the "US-Japan Joint Congress on Snake Control for Human Health and Wildlife Conservation" in Okinawa, Japan.
Sep 29-Oct 3	L. A. Fiedler W. B. Jackson	Egypt	Assess Egyptian rodent research and other vertebrate pest research and training needs.
Oct 11-Nov 11	J. E. McConnell	Chad	Conduct rodent monitoring, initiate pitfall traps, continue rodenticide trials, and trap animals for population studies.
Oct 28-Nov 24	M. E. Tobin	Bangladesh	Review 1992 bird research conducted by the BARI/VPS and help plan and initiate bird control studies for 1993, assess technical aspects of the 1992 Rodent Control Program, and provide technical assistance for rodent and predator research.
Nov 14, 1992, to May 1, 1993	R. L. Bruggers	Argentina	Identify areas for cooperative vertebrate pest research, review Ph.D. research in Argentina of Colorado State University graduate student, and conduct research on both the movements of radio-equipped blackbirds in rice and the usefulness of leg streamers as a marking technique.
Nov 27-Dec 19	J. E. Brooks	Chad	Complete remaining field and laboratory work of the RCRP and closeout the project.
1993			
Feb 14-Mar 8	M. M. Jaeger	Bangladesh	Assist BARI in monitoring the effectiveness of the annual National Rodent Control Campaign, and determine which rodenticides are available to Bangladesh farmers.
Apr 14-May 3	W. B. Jackson	Italy and Bangladesh	Assess the current research program strategies and priorities of BARI/VPS, and assist with designing and implementing a research program and research strategy for the 5-year period after the end of USAID funding on June 30, 1993.

Table 7. Continued.

Date	Name	Location	Purpose of trip
1993			
Apr 14-May 13	L. A. Fiedler	Italy, Bangladesh, and the Philippines	In Italy, visit FAO Headquarters, Crop Production and Protection Division personnel regarding vertebrate pest management projects and activities; in Bangladesh, evaluate the 1992 National Rodent Control Campaign and make recommendations for future rodent pest management operational programs and strategies; and in the Philippines, attend the "Agricultural Products Quality Workshop."
May 5-31	J. E. Brooks	Bangladesh	Close out the BARI/USAID/DWRC Vertebrate Pest Research Project which was functional in Bangladesh from 1978 to 1993.
Sep 6-28	R. A. Dolbeer	Chad	Conduct field work with MOA/Department of Plant Protection (DPV) personnel to monitor rodent populations at previously used study sites, and determine the status of rodent research and control work carried out by the DPV since the project ended in December 1992.
Sep 8-30	L. A. Fiedler	Niger	Assess rodent populations in agricultural areas of Niger using comparable methods being used in Chad for direct comparison, and present a 1-day workshop for crop protection personnel.
Sep 19-29	J. E. Brooks	Pribilof Islands	Recommend surveillance measures to prevent rat populations from establishing on the Pribilof Islands in Alaska.

Technical Assistance to Project Field Stations

Bangladesh

Mr. Lynwood Fiedler, DWRC wildlife biologist, visited the Bangladesh Agricultural Research Institute (BARI) between October 28 and November 26, 1991, to review past research and training accomplishments of the Vertebrate Pest Section (VPS) and plan future cooperative work. From October 15 to 29, the Department of Agricultural Extension (DAE)/MOA conducted a National Rodent Control Campaign. The DAE uses technology that has been developed with the DWRC during more than 10 years of cooperative research.

Dr. Richard Bruggers, Chief, IPRS, traveled to Bangladesh between March 28 and April 11, 1992, to meet with personnel from BARI/VPS, USAID, Bangladesh Rice Research Institute, and MOA/DAE. Dr. Bruggers consulted on research, extension, temporary duty assignments (TDY's), budgets, training, and general project implementation scheduled prior to June 1993.

Dr. David Saltz, wildlife biometrician who had conducted postdoctoral research with Princeton University and the Israel Nature Reserves Authority, consulted for DWRC in Bangladesh between April 9 and 29, 1992. Dr. Saltz provided guidance to the BARI/VPS in research study design and statistical analysis and use of SAS PC software. Dr. Saltz also analyzed data from the 1991 Bangladesh National Rodent Control Campaign. Data obtained from farmer interviews suggested that the campaign had an overwhelming impact with most farmers believing that the campaign reduced rat damage to crops. Evaluations following the September/October 1992 campaign were to concentrate on actual field evaluations of rat populations relative to rodent damage and potential crop saved.

Dr. Charles E. Harris, wildlife biologist from the Idaho Department of Fish and Game, Nampa, Idaho, consulted for DWRC in Bangladesh between April 14 and May 16, 1992. Dr. Harris visited the VPS/BARI to review progress of 1991-92 predator research on jackals, particularly damage assessment in sugarcane, advise on enclosure studies designed to measure the predator capacity of jackals and jungle cats on rodents, review draft manuscripts on jackal research, and help plan research for 1992-93. Dr. Harris recommended that BARI scientists continue to refine methodologies of sugarcane damage assessment, assess the effects of some simple animal husbandry practices on predation losses, and conduct a series of pen feeding trials on jackals and jungle cats to provide input into recently developed computer models which in turn might provide useful information regarding predation effects on rats, livestock, and crops.

Mr. Joe Brooks, DWRC wildlife biologist, consulted in Bangladesh between May 2 and June 11, 1992. His objective was to evaluate the 1991 National Rat Control Campaign in Bangladesh and suggest recommendations for improving the 1992 campaign. In Bangladesh, the 1991 campaign reached about 800,000 farmers; over 1 million rats were killed, thus saving an estimated 7,740 mt of rice.

Dr. Jeffrey Jackson, Professor at the Warnell School of Forest Resources, University of Georgia, consulted in Bangladesh between June 16 and July 15, 1992, to provide guidance

to strengthen the DAE's efforts in rodent control. Dr. Jackson assisted Mr. Santosh Sarker, DAE rodent extension specialist, with designing and drawing illustrations for extension posters and brochures; filming rice culture, important pest rodents, locations for baiting, and procedures for setting traps for a training video; and revising previous farmers' leaflets to include additional instructions and illustrations.

Dr. Mark Tobin, wildlife biologist from DWRC's Hawaii field station, traveled to Bangladesh between October 28 and November 24, 1992, to review 1992 bird research, help plan bird control studies for 1993, assess technical aspects of the 1992 Rodent Control Campaign, and provide technical assistance for rodent and predator research. Dr. Tobin also assisted in defining research objectives, designing study protocols, and collecting and analyzing data.

Dr. Michael Jaeger, zoologist from DWRC's Berkeley field station, consulted in Bangladesh between February 14 and March 8, 1993, to evaluate the various rodenticides that are available to Bangladesh farmers and assist the BARI in developing a sampling scheme for monitoring the effectiveness of their National Rodent Control Campaign.

Mr. Lynwood Fiedler and Dr. William Jackson, Professor Emeritus from Bowling Green State University, traveled to Bangladesh between April 19 and May 9, 1993, and April 19 and May 3, respectively. Mr. Fiedler evaluated the 1992 National Rodent Control Campaign conducted by the DAE in cooperation with the BARI/VPS to make recommendations for future rodent pest management operational programs and strategies. Dr. Jackson helped plan research priorities for the next 5 years. Large acreages of irrigated rice are now replacing seasonal wheat crops, and rodents are still considered the main vertebrate pest problem. A prime concern, central to effective rodent control in Bangladesh, is the problem of how to get zinc phosphide baits to the farmers for practical use. Dr. Jackson also participated in an FAO integrated pest management workshop for farmers.

Mr. Joe Brooks visited Bangladesh from May 5 through May 31, 1993, to close out the project. Mr. Brooks submitted a Project Assistance Completion Report (PACR) for this project. The PACR summarizes the project activities and findings, completion of the defined objectives and outputs, training given to counterpart scientists, the constraints on completion of project goals, lessons learned that apply to future projects, and recommendations for future research, cooperation, and followup evaluations.

Chad

Mr. Joe Brooks and Dr. Richard Dolbeer, wildlife biologist from DWRC's Ohio field station, consulted in Chad during August and September 1992. Mr. Brooks prepared budgetary and administrative documents and work plans for the balance of the project, and he revisited rodent monitoring sites at N'Gouri and Karal. Mr. Brooks, Dr. Dolbeer, and Dr. Maho Angaya, project assistant, presented a 5-day rodent research and control workshop in N'Djamena to 15 Chadians. Mr. Brooks also conducted laboratory toxicity studies of rodenticides on multimammate rats (*Mastomys natalensis*) and unstriped grass rats (*Arvicanthis niloticus*).

During September, Dr. Dolbeer conducted four rodenticide field trials in an agricultural area northeast of Lake Chad where rodent populations were moderately high. Zinc phosphide-treated millet was effective in reducing rodent populations in two wadis where hand-irrigated farming occurs. No nontarget mortality was noted. Results from trials with chlorophacinone-treated millet were not clear-cut. Two of three population-monitoring indices did not show reductions in rodent activity posttreatment. The use of zinc phosphide should be effective in reducing agricultural losses from rodents in this region of Africa. Additional field testing is needed for other rodenticides before firm recommendations can be made on their efficacy.

Mr. John McConnell traveled to Chad between October 11 and November 11, 1992, to assist counterpart MOA scientists in evaluating rodent monitoring and control techniques and studying rodent reproductive biology.

Mr. Brooks again traveled to Chad between November 27 and December 19, 1992, to complete research on rodent population monitoring methods and close out the project. The principal finding of this monitoring was that one single method of rodent population monitoring is inadequate for mixed species of rodent communities.

Mr. Brooks visited the Smithsonian Institution's National Museum of Natural History in Washington, D.C., during the week of February 22, 1993, to review identification of the Sahelian rodent species from Chad. By using the mammal collection and consulting with Smithsonian experts, Mr. Brooks determined that the previously referenced agag gerbil was actually the lesser hairy-footed gerbil (*Gerbillus gerbillus*), the Lake Chad gerbil was correctly identified as the slender gerbil (*Taterillus* spp.), and the fringe-tailed gerbil was actually the robust gerbil (*Tatera robusta*).

Dr. Dolbeer consulted between September 6 and 28, 1993, to monitor rodent populations and compare several monitoring methods; he also evaluated research and control work carried out by the CPS since December 1992. This was DWRC's last scheduled consultancy to Chad under the USAID-funded project.

Morocco

Dr. Michael Avery, Dr. James Keith, Mr. Keith LaVoie, and Dr. Patricia Matteson, entomologist from Iowa State University, worked in Morocco between October 6 and 27, 1991, to train 18 Moroccan scientists in applied field techniques of ornithology, ecotoxicology, mammalogy, and entomology. A manual of ecotoxicological techniques was produced.

During January and February 1992, 12 scientists from the DWRC, ADC Operations, EPA, and Iowa State University traveled to Morocco to assist in research to evaluate the environmental impact and nontarget risk of large-scale locust control sprays. Results of this research have been incorporated into a manuscript for publication. This study culminated 2½ years of training and research to provide information to the GOM on the impact of these insecticides in arid environments of southern Morocco.

Technical Assistance to Other Countries

Rodent Research in West Africa

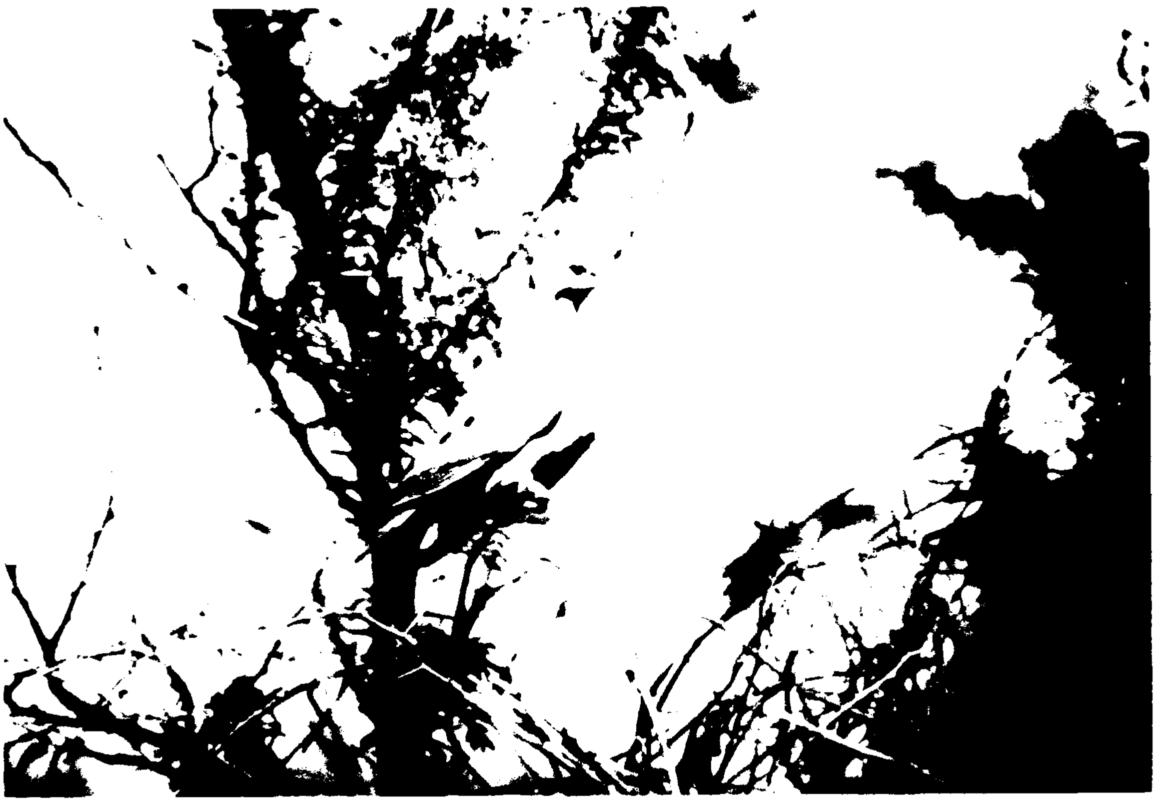
Mr. Joe Brooks traveled to Senegal between March 11 and 28, 1992, to assess rodent populations at five sites in the Senegal River Valley and at four sites in the peanut basin area. The dominant rodent species in the valley was the unstriped grass rat (*Arvicanthis niloticus*), followed by one species of the multimammate rat complex (*Mastomys* [=*Praomys*] *huberti*.) Rodent densities were higher than normal in irrigated vegetable plots near Dagana and St. Louis and in wet ditches in fallow rice fields near Richard Toll. Rodent densities were low in the peanut basin at all sites, based both upon trapping and burrow counting efforts. Both *Arvicanthis* and *Mastomys* showed evidence of a strong breeding effort just 2 to 3 months ago: 79% of 14 captured *Mastomys* were sexual immatures, and 49% of 37 *Arvicanthis* were immatures. Two of four adult female *Arvicanthis* were pregnant, indicating the normal post-rainy season breeding effort had been prolonged. These two pest rodent species could reach outbreak populations if the next two rainy seasons are normal or above, since the 30-year rainfall average in Senegal indicates precipitation has been below normal in the preceding 2 years.

Mr. Fiedler consulted in Burkina Faso, Côte d'Ivoire, Mali, and Niger between March 17 and April 13, 1992, to determine the current status of agricultural pest rodent populations in Sahelian countries, assess the availability of appropriate rodent population monitoring sites, and determine the interest in establishing a regional rodent monitoring network to forecast rodent population outbreaks.

Mr. Fiedler also consulted again in Niamey, Niger, between September 7 and 30, 1993. In cooperation with crop protection personnel of the Government of Niger, Mr. Fiedler used different monitoring methods to survey rodent activity in two agricultural areas. Multimammate rat (*Mastomys* sp.) and Nile rat (*Arvicanthis* sp.) populations appeared to be low based on trapping, counting burrows, and use of tracking tiles. Gerbil (*Gerbillus* sp.) populations in millet fields appeared to be at moderate levels based on trap success and burrow counts. Mr. Fiedler also presented a 1-day rodent control workshop in Zinder for 21 agricultural agents from different regions of Niger. French copies of a training manual on rodent research and control, which had been developed by the Chad Rodent Control Research Project, were given to each participant.

Control of Bird Pests in Argentina and Uruguay

Between September 20 and October 11, 1991, Mr. Roger Bullard, DWRC research chemist, completed his second consultancy to Argentina and Uruguay to present six lectures to approximately 30 individuals in a 5-day, binational training course on integrated control of bird problems in agricultural crops in these two countries. Mr. Bullard discussed bird repellents and nonlethal methods of damage control as well as ecotoxicological concepts and applications. During this trip, Mr. Bullard also helped plan research, design testing facilities, and observe pigeon damage problems in emergent sunflowers.



Monk parakeets (*Myiopsitta monachus*) [above] and eared doves (*Zenaida auriculata*) [below] can cause serious damage to sunflowers in Argentina.

In northwest Argentina, fruit growers consider parrots a pest of citrus, such as grapefruit, lemons, and oranges.

In some areas of Argentina, the Red fox (*Dusicyon culpaeus*) preys on livestock such as sheep.

Dr. Michael Jaeger and Dr. Richard Bruggers traveled to Argentina and Uruguay from December 9 to 20, 1991, to demonstrate the use of various marking agents for assessing activity of eared doves at baits sites and examine possibilities for use of CPT formulated in amorphous silica gel as a toxicant for monk parakeets at nest sites to replace the currently used endrin grease formulations.

Dr. Richard Bruggers spent approximately 6 months between November 1992 and May 1993 on a sabbatic in Argentina, where he was hosted by the Government of Argentina, National Institute of Agricultural Technology (INTA). While in Argentina, Dr. Bruggers began to learn Spanish, identified a number of areas of animal damage research in which DWRC and INTA could collaborate, taught in a Wildlife Management Short Course at the University of Cordoba, reviewed the Ph.D. research of Ms. Maria Elena Zaccagnini, graduate student at Colorado State University, and conducted research on both the movements of radio-equipped Chestnut-capped Blackbirds (*Agelaius ruficapillus*) in and around maturing rice schemes and the usefulness of leg streamers as a marking techniques for blackbirds. During this period, Dr. Bruggers also visited Uruguay regarding bird pest research.

Vertebrate Pest Management in Southeast Asia and Eastern Africa

Mr. Joe E. Brooks consulted in India between May 29 and June 4, 1992, to explore the possibility of cooperative vertebrate pest management research between the University of Agricultural Sciences in Bangalore, India, and the DWRC.

Mr. Lynwood Fiedler and Dr. William Jackson traveled to Egypt, Hong Kong, India, Indonesia, Malaysia, the Philippines, and Thailand between August 26 and October 3, 1992, to assess current rodent research and control activities, determine in-country capabilities, and identify knowledge and implementation gaps in rodent control. Vertebrate pests, especially rodents, were among the top three problems in each country visited; and in some, rodents headed the list. A small working conference of indigenous scientists, international experts, and donor representatives to define and prioritize regional research and training needs and plan for the support of initial efforts was proposed. Other recommendations included regional workshops that would focus on specific VPM problems. Several recommendations addressed research concerns including better use of rodent damage surveillance and monitoring data.

In Egypt, Mr. Fiedler and Dr. Jackson discussed vertebrate pest problems with personnel of the USAID/Agricultural Development Office, MOA/National Agricultural Research Project, Plant Protection Research Institute, Egyptian/German Rodent Control Project, and university staff at Ain Shams, Alexandria, Cairo, and Zagazig.

Between April 14 and 19, 1993, Mr. Fiedler met with personnel of FAO/Crop Production and Protection Division, Rome, to discuss past, present, and future vertebrate pest management projects and activities; and Mr. Fiedler submitted his manuscript on "Eastern Africa Rodent Pest Management." Dr. William Jackson was there simultaneously to consult with FAO/Crop Protection officials regarding vertebrate pest problems in Asia and Africa.

Vertebrate Pest Control Research in Pakistan

Between November 1985 and June 1991, the DWRC provided technical assistance through USAID to the Government of Pakistan's Vertebrate Pest Control Laboratory (VPCL) at the National Agricultural Research Centre (NARC) in Islamabad. Mr. Joe Brooks consulted in Pakistan between May 2 and 8, 1992, to evaluate current and future research, training, and technology transfer programs of the VPCL. The VPCL/NARC is functioning effectively; it has submitted a 3-year research workplan with budget and has published or submitted 11 research articles, and it continues to be very active in training and research. Between September and October 1991, it offered its seventh consecutive annual vertebrate pest management training workshop to 17 participants from all but one province of the country. In addition, articles on vertebrate pests of groundnuts and guava were published, and field trials were initiated of rodenticide efficacy to rodents in groundnuts and baiting for wild boar.

The lesser bandicoot rat (*Bandicota bengalensis*) has been found to reduce groundnut production by 44% in rat-infested fields in Pakistan. Results showed that four biweekly applications of three anticoagulant baits to bandicoot burrows in about 50 farmers' groundnut fields near Chakwal reduced rodent activity (burrow counts/ha) by an average of 90% over the baiting period and resulted in an 80% increase in groundnut production as compared to nearby untreated controls. Although no difference was noted in effectiveness among the anticoagulants used, coumatetralyl (Racumin®) was preferred because it was the most economical.

Studies of the ecotoxicology of zinc phosphide in animals and the environment are being carried out by Mr. Shahid Munir, scientific officer, VPCL/NARC. Mr. Munir spent 6 weeks at DWRC/Denver and field stations in 1989, learning chemical residue methodology, rodent capture-mark-release-recapture and radiotelemetry methods, field collection and preparation of animal tissues; he prepared a research proposal for these studies in Pakistan. Mr. Munir has completed the first two of the eight phases of his study: determining the pH values of the stomach of the lesser bandicoot rat (*Bandicota bengalensis*) under various feeding conditions and the purity of zinc phosphide samples collected from markets in Pakistan. Mr. Munir will continue the balance of his ecotoxicology studies at Punjab University, Lahore, in partial fulfillment for a Ph.D. degree.

Mr. Iftikhar Hussain, scientific officer at the VPCL, has been accepted as a Ph.D. candidate by the Department of Zoology, Punjab University, Lahore, and has started his Ph.D. research on the food habits and reproduction of rodent pests of the Pothwar Plateau, Pakistan.

Mr. Abdul Aziz Khan, principal scientific officer at the VPCL, has been finishing his dissertation for submission to Karachi University in partial fulfillment for a Ph.D. degree.

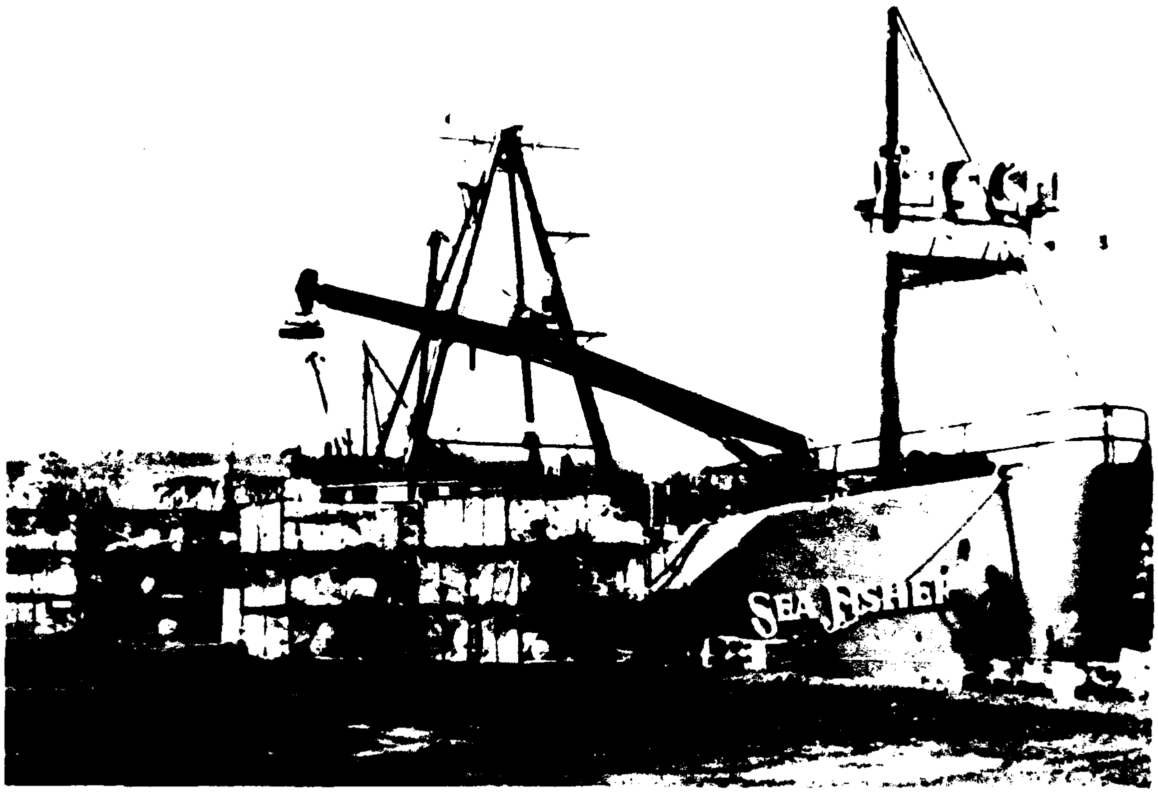
Left: Aziz Khan, VPCL unit leader, holds baits developed for wild boar control.
Right: Shahid Munir and Aziz Khan, Pakistani counterparts

Iftikhar Hussain displays readymade zinc phosphide baits in the laboratory.

Prevention of Rat Infestations on the Pribilof Islands

Mr. Joe Brooks consulted in the Pribilof Islands of Alaska at the request of the FWS from September 19 to 29, 1993, to assess the potential of rat infestations on island environments in the Alaska Maritime National Wildlife Refuge and to recommend measures to prevent such rat infestations reaching the Pribilof Islands. During his consultancy, Mr. Brooks reviewed the rodent situation on St. Paul and St. George Islands, trained local people on rodent detection and prevention, and evaluated procedures and ordinances regarding rodent inspections on ships. A proposal/concept paper is being prepared for followup activities.

Village of St. George in the Pribilof Islands.



Crab traps are unloaded on St. Paul Island to be stored until the next crab season. The traps could provide a temporary food source and harborage for Norway rats should these rats reach the island.

Bait boxes were installed in St. Paul harbor as part of a monitoring system to detect invading rats.

Brown Tree Snake Research in Guam

DWRC participated in several activities in brown tree snake (*Boiga irregularis*) research and management under its Interagency Agreement with USDI/FWS/National Ecology Research Center. Several DWRC scientists were in Guam during September and October 1991 to conduct methyl bromide fumigation tests on brown tree snakes. A simulated nonfood cargo situation was established to evaluate the effectiveness of methyl bromide as a fumigant to brown tree snakes. Eighteen snakes were randomly positioned in a 1,685-ft^3 cargo container for each fumigation test. Methyl bromide was applied at rates of 1.5 lbs/2 hrs, 1.5 lbs/1 hr, 0.75 lbs/2 hrs, and 0.75 lbs/1 hr, all per 1,000 ft^3. All snakes died within about 18 hrs at the 1.5 lbs/2 hrs rate and within 2+ days at 0.75/2 hrs. Thirty-two of 36 snakes were dead after 3 days at the 1.5 lbs/1 hr rate, but all were dead by 11 days. Only one snake was dead after 10 days at the 0.75 lbs/1 hr rate. Methyl bromide is registered with the Environmental Protection Agency for many fumigation purposes and is regularly used on Guam. Modification of certain registration labels will hopefully make it available as a tool to help reduce snake dispersal to other Pacific islands.

Dr. Peter Savarie, DWRC research pharmacologist, traveled to Guam and Japan between September 16 and October 1, 1992, regarding control methods for management of the brown tree snake (*Boiga irregularis*). Dr. Savarie attended a briefing in Guam held by the FWS on their proposed FY-93 activities, and he then traveled to Japan to participate in the U.S.-Japan Joint Congress on Snake Control for Human Health and Wildlife Conservation in Okinawa, September 27-30. The purpose of this Congress was to promote exchange of information between Japanese and American scientific teams regarding the ecology and behavior of the brown tree snake, including sensory organs, reproduction and pheromones, circumstances of the bites, and snake control methods such as trapping, use of electric fences, and use of attractants. Dr. Savarie's presentation was on "Candidate repellents, oral and dermal toxicants, and fumigants for brown tree snake control."

On May 20, 1993, Dr. Richard Bruggers represented the DWRC at the First Meeting of the Aquatic Nuisance Species Task Force's Brown Tree Snake Control Committee in Honolulu, Hawaii. The purpose of this Committee was to develop a comprehensive program that includes elements of education, prevention, and research for the brown tree snake. The Committee was composed of representatives of the Department of Defense/Armed Forces Pest Management Board, USDI/FWS, and National Wildlife Health Center, USDA/ADC Operations and Research, USDA/APHIS Program Planning and Development, and representatives of Hawaii, Guam, and Saipan.

Supportive Research Activities

The DWRC hosted international scientists from several countries for various short visits and long-term sabbaticals.

Mr. Ejaz Ahmad, a Ph.D. candidate at Colorado State University (CSU) in Fort Collins from the Vertebrate Pest Control Project in Pakistan, is conducting his Ph.D. research at the DWRC in cooperation with the Biotechnology Unit/Product Development Section to

compare the effectiveness of two oral delivery vaccine systems—the biodegradable microsphere and the liposome—given to the wild Norway rat (*Rattus norvegicus*).

Dr. Shakunthala Sridhara from the University of Agricultural Sciences, Bangalore, India, visited the DWRC on March 9-10, 1992, to discuss mutual research interests and cooperation in rodent research.

Moroccan scientists Messrs. Said Ghaout, Abderrahim El Hani, and El Hassan Arroub, visited the DWRC between April 26 and May 16, 1992, to help prepare the final report of cooperative research on insecticide impacts conducted in Morocco. Messrs. Ghaout, El Hani, and Arroub also met with entomologists ar·' ecotoxicologists at CSU and Utah State University (USU) to discuss their interest in controlling desert locusts (*Schistocerca gregaria*) in Morocco without harming the environment.

The DWRC hosted international scientists, Mr. Md. Emdadul Haque from Bangladesh and Mr. Lee Choon Hui from Malaysia, between June 8 and 12, 1992. Both individuals visited DWRC as part of an international short course in Vertebrate Pest Management which was offered at Bowling Green State University (BGSU). Prior to visiting Denver, they spent 1 day at the DWRC field station in Sandusky, Ohio. This was the second year DWRC cooperated with BGSU in this international training endeavor.

During November 1992, Dr. William Andelt and 11 students from his Managing Human-Wildlife Conflicts class at CSU visited the DWRC to experience some ongoing research activities. They toured the library, bioelectronics laboratory, and other facilities to observe bird research, immunocontraception studies, and bait formulation.

In 1993, Dr. Md. Sayed Ahmed, former Scientific Officer at the Bangladesh Rice Research Institute (BRRI), returned to DWRC to help prepare several scientific manuscripts on vertebrate pest problems in Bangladesh and draft a training manual on vertebrate pest management for use in Bangladesh.

Mr. Robert Oudinet, Director of the Normandy Regional Crop Protection Service of the French MOA, and Mr. Patrice Prevel, representing the Chambre d'Agriculture (farm bureau) from La Manche, Normandy, visited the DWRC from March 11 to 15, 1993, to learn of developments in bird control techniques, particularly on the use of CPT (3-chloro-*p*-toluidine) as a roost toxicant. They were also interested in rodent control and the problems of anticoagulant resistance.

Mr. Habibur Rahman from the Bangladesh Agricultural Research Institute at Joydebpur visited the DWRC on April 29 to 30, 1993, and then spent the month of May at the Ohio field station where he received training in vertebrate pest control research, particularly for birds. Mr. Rahman received training in the capture and handling of birds, experimental design and methodology for testing repellents, use of radiotelemetry and color marking for determining movements of birds, analyses of data, and methods for determining feeding habits of birds.

Dr. Abdelkader Zaime of the Institut Agronomique et Veterinaire Hassan II in Rabat, Morocco, visited the DWRC between July 19 and 23, 1993, to work with Messrs. Joe Brooks and Lynwood Fiedler in developing a cooperative research proposal on the subject of "Factors affecting population cycles and development of a prediction model for pullulation in gerbils."

Dr. Mohamed Farag El-Sayed, Physiology Department, Egyptian Plant Protection Research Institute, Geiza, Egypt, visited the DWRC between July 23 and August 2, 1993, to become more familiar with ADC research in the United States. Dr. Farag was on an 8-month postdoctorate fellowship, sponsored by the USAID, to BGSU where he was conducting research on methods of detection, mechanisms of anticoagulant resistance, and control of populations of house mice (*Mus musculus*) in postharvest situations for application in Egypt.

Ms. Ethel Rodriguez, Head, Department of Bird Pests/Plant Protection Division/MOA in Montevideo, Uruguay, spent 3 months at the DWRC during the summer of 1993. Ms. Rodriguez is a Ph.D. candidate in the Department of Fishery and Wildlife Biology at CSU. While at Denver, she completed the first draft of her research thesis entitled "Strategy development in the use of secondary repellency for reducing Eared Dove damage on sorghum crops."

Research Studies

Messrs. Lynwood Fiedler, Dr. Ping Pan, and Mr. Peter Johns completed a pilot study to examine the potential for aspirin to release bound warfarin in rats and render it available for anticoagulant rodenticidal action. Various combinations of warfarin (0.005%) and aspirin (1-10%) in plain lab chow were offered to Norway rats (*Rattus norvegicus*). Although consumption of all baits with aspirin was much lower than normal, necropsies suggested that aspirin increased the degree of hemorrhaging in warfarin-fed rats.

Another pilot study was completed at the DWRC to investigate the feasibility of using electrified water barriers to repel rats. Moats were constructed, and Norway rats were conditioned to cross the water, feed, and return to daytime resting structures. After acclimation occurred, the moat was electrified with a nonlethal current. The degree of repellency was determined by measuring food consumption and by video recording. After adjusting the width of the electric field and adding an overhead obstruction that produced a smooth swim pattern, rats were completely repelled. This electrified moat design may have practical application in repelling rats from crop areas, such as irrigated rice, surrounded by water canals.

Participation in Meetings, Conferences, and Seminars

Dr. Richard Bruggers attended Centers Week at the World Bank in Washington, D.C., between October 28 and November 1, 1991. Centers Week is the annual meeting of the Consultative Group on International Agricultural Research (CGIAR) Centers. These centers were established to examine the needs of developing countries for agricultural research at

the international level, encourage complimentary research through information exchange, consider financial requirements of high priority research, assess feasibility of specific proposals, and review international agricultural research priorities. This current group of international centers numbers 16, including the International Rice Research Institute (IRRI) in the Philippines, International Maize and Wheat Improvement Center (CIMMYT) in Mexico, and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India, all of which have cooperated with DWRC on vertebrate pest management issues.

Dr. James Keith attended the Regional Environmental and Natural Resources Management Project's (RENARM) annual coordinator's meeting between December 2 and 5, 1991, in Managua, Nicaragua. RENARM addresses environmental and natural resource issues in Central America through several initiatives including natural resource policy; environmental awareness, education, and biodiversity; sustainable agriculture and forestry including regional plant protection; and institutional development and technical training. The meeting was attended by, among others, individuals from the USAID, USDA, OICD, the Peace Corps, Environmental Protection Agency, and Central American regional training and conservation organizations.

Several DWRC scientists presented overviews of Center research to the Armed Forces Pest Management Board on January 14, 1992. This Board annually reviews the U.S. Department of Agriculture's research of interest to the Department of Defense. This included summaries of DWRC's research program, brown tree snake research, bird hazards to aircraft, chemical registration research, oral bait delivery systems for mammals, and immunocontraception/Lyme disease research.

Dr. Peter Savarie presented a talk on the brown tree snake problems in Guam to about 50 members of the Arapahoe Sertoma Club, Englewood, Colorado, on January 16, 1992; and on October 12, 1992, Mr. Joe Brooks met with this same group to inform them about the biology, distribution, and habits of rodents. The Sertoma Club is an international civic organization with local affiliated clubs working in various ways (drug education, sponsorships of speech and hearing clinics) to serve their communities.

Mr. Joe Brooks presented a lecture on storage pest problems at the "Short course in bulk grain handling and storage management" which was held for 20 Pakistani participants at Kansas State University in Manhattan, Kansas, on September 28 and 29, 1992.

Mr. Brooks presented a paper on "The status of the Eurasian wild boar in Pakistan" at the Feral Swine Symposium on March 24-25, 1993, in Kerrville, Texas. Feral swine occur in 19 states in the United States. Feral swine constitute both a valuable huntable resource, but also a tremendous liability because of their impact on the environment and disease transmission to domestic livestock. The symposium was jointly sponsored by the Texas Agricultural Extension Service, Texas Animal Damage Control, Texas Parks and Wildlife Department, and USDA/APHIS.

The First International Congress of the Society of Environmental Toxicology and Chemistry (SETAC) was held in Lisbon, Portugal, between March 28 and 31, 1993. Special sessions were held on marine pollution, agricultural contamination of surface waters, pesticide

metabolism, pollution by heavy metals, pesticide regulation issues, and predictive models for pesticide hazard assessment. In addition, a large number of papers were presented on contaminant effects in the environment. Between 1985 and 1992, the DWRC conducted four studies of the use of Queletox® and locust insecticides in Africa. Dr. Keith attended the Lisbon meeting and presented findings of this African research by our Center. The following studies were summarized at the meeting: the effects of aerially applied fenitrothion and chlorpyrifos on birds in the savannah of northern Senegal, environmental effects on wetlands of Queletox applied to ploceid roosts in Kenya, impact of fenthion on nontarget birds during quelea control in Kenya, and effects of experimental applications of malathion and dichlorvos on populations of birds, mammals, and insects in southern Morocco.

During April 20 and 21, 1993, Mr. Brooks visited Washington, D.C., where he participated in a panel discussion regarding the feasibility of establishing an international electronic bulletin board for crop protection. This panel was co-sponsored by the Consortium for International Crop Protection (CICP) and the USDA/Cooperative State Research Service. Mr. Brooks also met with USAID officials to discuss DWRC research and training activities in the West African countries and USAID's new Integrated Pest Management (IPM) initiative.

Mr. Lynwood Fiedler traveled to the Philippines to participate on the APHIS panel in the USAID-sponsored Asia/Pacific Regional "Agricultural Products Quality Workshop" being held in Manila on May 11 and 12, 1993. He presented a paper on "Vertebrate pests as constraints to agricultural production and quality in the Asia/Pacific Region" and exchanged information on specific problems of rodents, birds, and other vertebrate pests affecting a variety of private agribusiness ventures within the region.

Dr. Keith presented a paper on "Insecticides: why are animals killed only some of the time?" at the International Union of Game Biologists XXI Congress in Halifax, Canada, from August 15 to 20, 1993.

Mr. Brooks represented USDA on the CICP Executive Board at a meeting in Las Vegas from June 23 to 25, 1993. CICP is a consortium of 13 land-grant universities and the USDA, and it is devoted to international crop protection projects. Items on the Executive Board's agenda included discussion on the establishment of a global electronic IPM bulletin board and the direction that the CICP member universities are taking in the matter of USAID's IPM Collaborative Research Support Program (CRSP) proposal.

Dr. Bruggers and Dr. Gary Witmer, DWRC field station in Pullman, Washington, attended the First International Wildlife Management Congress in San Jose, Costa Rica, between September 19 and 25, 1993. This Congress was primarily sponsored and organized by The Wildlife Society. About 700 individuals from 70 countries attended. Dr. Bruggers was coauthor of a poster session on blackbird problems in rice in Argentina, and Dr. Witmer also coauthored a poster session on international rodent problems and presented a paper on predator control and conservation in Costa Rica. The Congress theme was "Integrating people and wildlife for a sustainable future" and emphasized development of wildlife conservation strategies that attend to the needs of people and conservation strategies that focus on biological diversity, with the hope of developing an international vision for

management of wildlife resources for the 21st century. Presentations addressed such diverse topics as international trade in wildlife products, human populations and education considerations in wildlife management, ecotourism conflicts between man and agriculture, implementing wildlife management progress, and techniques for monitoring habitat and wildlife species.

Note: Nearly all of this travel was funded by sources other than USAID; it is included only for purposes of completion in this last USAID Annual Report.

A Senegalese villager holding an African giant rat (*Cricetomys gambianus*) that had been trapped in a village market.

International Programs Research Section[1,2]

Richard L. Bruggers	Chief
Jean A. Alleman	Program Assistant
Joe E. Brooks	Wildlife Biologist
Lynwood A. Fiedler[a]	Wildlife Biologist
Marilyn A. Harris	Editorial Assistant
Peter J. Johns[b]	Biological Technician
James O. Keith[c]	Wildlife Biologist (Intermittent)
John E. McConnell[d]	Logistics Coordinator (Morocco)
J. Juan Spillett[e]	Wildlife Biologist (Chad)
Kitty Stark[f]	Office Automation Clerk

[a] Mr. Fiedler transferred to the Mammal Research Section in June 1993.
[b] Mr. Johns left his position on April 29, 1993.
[c] Dr. Keith retired on August 8, 1992, but returned to work intermittently with the IPRS since January 17, 1993.
[d] Mr. McConnell worked with IPRS in Morocco between May 1, 1990, and June 3, 1992. In November 1992, he began working at the Logan field station of DWRC's Mammal Research Section.
[e] Dr. Spillett worked with IPRS in Chad between on July 3, 1990, and December 10, 1991.
[f] Mrs. Stark began working with IPRS as Miss Kitty Roettger on February 24, 1992; on August 10, 1993, Mrs. Stark transferred from the DWRC to the ADC Office in Olympia, Washington.

Bangladesh (Counterpart Personnel)

Abdul Karim	Head, Division of Entomology
Emdadul Haque	Senior Scientific Officer
[g] Parvin Sultana	Senior Scientific Officer
Yousuf Mian	Senior Scientific Officer
Rajat Kumar Pandit	Scientific Officer
Habibur Rahman	Scientific Officer
Mahtab Uddin	Laboratory Technician
Jalal Uddin	Clerk/Typist

[g] Dr. Parvin Sultana left the VPS to become a private consultant in early 1992.

[1] Fully funded under a Participating Agency Service Agreement (PASA).
[2] The International Programs Research Section (IPRS) was changed to the International and Special Programs Unit of the DWRC, effective May 2, 1993.

Chad (Counterpart Personnel)

Maho Angaya[a]	Project Assistant
Djibo Koulangar[b]	Project Technician
Delassoum Richard[c]	Chauffeur
Mahamat El-Hadji N'Gaba[d]	Chauffeur
Dilemko Louis[e]	Janitor/Animal Keeper

[a] Dr. Angaya was Project Assistant between November 1991 and December 1992.
[b] Mr. Koulangar joined the Project in March 1990.
[c] Mr. Richard worked for the Project from July 1990 until December 1991.
[d] Mr. N'Gaba was Project chauffeur between August 1992 and December 1992.
[e] Mr. Louis worked for the Project from July 1990 until December 1992.

PARTICIPATION in MEETINGS, CONFERENCES, and SEMINARS

Bruggers, R. L. Attended Centers Week at the World Bank in Washington, D.C., Centers Week is the annual meeting of the Consultative Group on International Agricultural Research (CGIAR) Centers. October 28-November 1, 1991.

Keith, J. O. Attended the Fourth Coordination Meeting of the USAID/Regional Office for Central American Programs (ROCAP), Regional Environmental and Natural Resources Management Project's (RENARM) meeting in Managua, Nicaragua. December 2-4, 1991.

Bruggers, R. L. Attended the 15th Vertebrate Pest Conference in Newport Beach, California. March 3-5, 1992.

Jaeger, M. M. Presented a paper on "Control strategies to reduce preharvest rat damage in Bangladesh" at the 15th Vertebrate Pest Conference in Newport Beach, California. March 3-5, 1992.

Savarie, P. J. Presented a paper on "Candidate repellents, oral and dermal toxicants, and fumigants for brown tree snake control" at the "US-Japan Joint Congress on Snake Control for Human Health and Wildlife Conservation" in Okinawa, Japan. September 27-30, 1992.

Brooks, J. E. Presented a paper on "The Status of the Eurasian Wild Boar in Pakistan" at the Feral Swine Symposium in Kerrville, Texas. March 24-25, 1993.

Keith, J. O. Presented an abstract on "Environmental consequences of *Quelea quelea* and *Schistocerca gregaria* control programs in Africa" at the First Society of Environmental Toxicology and Chemistry (SETAC) World Congress on Ecotoxicology and environmental Chemistry—a Global Perspective, which was held in Lisbon, Portugal. March 28-31, 1993.

Brooks, J. E. Participated in a panel discussion in Washington, D.C., regarding the feasibility of establishing an international electronic bulletin board for crop protection. This panel was co-sponsored by the Consortium for International Crop Protection (CICP) and the USDA/Cooperative State Research Service. April 20-21, 1993.

Fiedler, L. A. Presented a paper on "Vertebrate pests as constraints to agricultural production and quality in the Asia/Pacific Region" on the APHIS panel in the USAID-sponsored Asia/Pacific Regional "Agricultural Products Quality Workshop" held in Manila, Philippines. May 11-12, 1993.

Bruggers, R. L. Represented the DWRC at the First Meeting of the Aquatic Nuisance Species Task Force's Brown Tree Snake Control Committee in Honolulu, Hawaii. May 20, 1993.

Brooks, J. E. Represented USDA on the CICP Executive Board at a meeting in Las Vegas from June 23 to 25, 1993. CICP is a consortium of 13 land-grant universities and the USDA, and it is devoted to international crop protection projects.

Keith, J. O. Presented a paper on "Insecticides: why are animals killed only some of the time?" at the International Union of Game Biologists XXI Congress in Halifax, Canada. August 15-20, 1993.

Bruggers, R. L., and G. Witmer. Attended the First International Wildlife Management Congress, primarily sponsored and organized by The Wildlife Society, in San Jose, Costa Rica. September 19-25, 1993. Dr. Bruggers coauthored a poster session on blackbird problems in rice in Argentina; Dr. Witmer coauthored a poster session on international rodent problems and presented a paper on predator control and conservation in Costa Rica. The Congress theme was "Integrating People and Wildlife for a Sustainable Future" and emphasized development of wildlife conservation strategies that attend to the needs of people and conservation strategies that focus on biological diversity, with the hope of developing an international vision for management of wildlife resources for the 21st century.

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Brooks, J. E., and E. Ahmad. 1993. The status of the Eurasian wild boar in Pakistan. Pages 117-127 *in* C. W. Hanselka and J. F. Cadenhead, eds., Feral Swine: A Compendium for Resource Managers, Proceedings of a Conference, March 24-25, 1993, Kerrville, Texas. 169 pp.

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Keith, J. O., J. G. Ngondi, R. L. Bruggers, B. A. Kimball, and C.C.H. Elliott. In press. Environmental effects on wetlands of Queletox applied to ploceid roosts in Kenya. (Accepted by Environmental Toxicology and Chemistry.)

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Spillett, J. J. and J. E. Brooks. Chad Rodent Control Research Project Progress Report, 1989-1991. A cooperative program of Government of Chad/Ministry of Agriculture, U.S. Agency for International Development, and U.S. Department of Agriculture/Animal and Plant Health Inspection Service/Denver Wildlife Research Center; Denver, Colorado. October 1991. 21 pp. and 3 appendices.

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Rat Facts, No. 12. Bait preference by the Nile rat. Chad Rodent Control Research Project, N'Djamena, Chad. December 1991.

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Fiedler, L. A., and W. B. Jackson. 1992. Vertebrate pest management in Egypt. Trip Report—Egypt. 6 pp. and 1 appendix.

Fiedler, L. A., and W. B. Jackson. 1992. Vertebrate pest management in tropical Asia. Trip Report—Philippines, Indonesia, Thailand, Malaysia, Hong Kong, and India. 36 pp. and 3 appendices.

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Savarie, P. J. 1992. Brown Tree Snake activities in Guam and snake meeting in Okinawa, Japan. Trip Report—Guam and Japan. 6 pp. and 1 appendix.

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Tobin, M. E. 1992. Review of vertebrate pest research: Bangladesh. Trip Report—Bangladesh. 7 pp. and 4 appendices.

<u>Other Reports and Documents</u>

Brooks, J. E. Final Report: Bangladesh Vertebrate Pest Project, 1978-1993. Project Assistance Completion Report. Unpublished Report, Denver Wildlife Research Center, Denver, Colorado. June 4, 1993. 20 pp. and 4 appendices.

Bruggers, R. L. 1993. Final Report on FY-93 Sabbatical Program (November 15, 1992-May 1, 1993), National Institute of Agricultural Technology (INTA), Parana, Argentina. Unpublished Report to Denver Wildlife Research Center, Denver, Colorado. 5 pp. and 4 appendices.

Fiedler, L. A. 1993. Rodent control techniques used in eastern Africa. Chapter 3 in Rodent Pest Management in Eastern Africa, a summary of rodent pest problems in agriculture and health, current methods of control, and some suggested management techniques. Submitted to FAO, Rome.

Fiedler, L. A. 1993. Suggested rodent pest management research strategies. Chapter 4 in Rodent Pest Management in Eastern Africa, a summary of rodent pest problems in agriculture and health, current methods of control, and some suggested management techniques. Submitted to FAO, Rome.

Keith, J. O., Study Director. Study Plan on Effects of experimental applications of malathion and dichlorvos on populations of birds, mammals, and insects in southern Morocco. Denver Wildlife Research Center, Consortium for International Crop Protection, and Government of Morocco. Denver, Colorado. December 9, 1991. 26 pp.

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Mullié, W. C. and J. O. Keith. Locusticide impact on birds in northern Senegal. Poster Session Handout at Eighth Pan-African Ornithological Congress. Bujumbura, Burundi. September 30-October 5, 1992.

Training Manuals

Chad Rodent Research and Control Project. Training Manual: Rodent Research and Control. 1992. USAID/Chad, Ministry of Agriculture/Crop Protection Service, and USDA/APHIS/Denver Wildlife Research Center, Denver, Colorado. 90 pp.

Projet Recherche sur le Contrôle des Rongeurs au Tchad. Les recherches et la lutte contre les Rongeurs, Manual de la Formation. L'USAID/Tchad, Ministere de l'Agriculture/Direction de Protection des Vegetaux, et L'USDA/APHIS/Denver Wildlife Research Center. Decembre 1992. 109 pp.

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Note: Further information on special reports or publications can be obtained from the authors or the agency for which the report was prepared.

Date	Name	Representing
1991		
Oct 7, 1991	Dr. Peter Greig-Smith	Ministry of Agriculture Worplesdon, United Kingdom
Nov 4	Dr. Harry Payne	MacFarlan Smith, Ltd. Edinburgh, Scotland
Nov 7	Dr. R. C. Bigalke	Department of F&W Biology Colorado State University (CSU), Fort Collins, Colorado and University of Stellenbosch South Africa
Nov 7, 1991, Apr 9, 1992, and periodically in 1993	Mr. Ejaz Ahmad	CSU (Pakistani graduate student)
Nov 14-15	Mr. Arvo Myllymaki	Agricultural Research Centre Institute of Plant Protection Jokioinen, Finland
1992		
Jan 14-16	Dr. Roy Ellis	Armed Forces Pest Management Board Department of National Defense, Ottawa, Canada
Feb 27, 1992	Mr. & Mrs. David Drummond	Ministry of Agriculture Fisheries & Food Dorking, United Kingdom
Feb 28	Mrs. Sue Scott and Aidan	Ilkeston, Derbyshire United Kingdom
Mar 6	Dr. Charles Eason	Forest Research Institute Christchurch, New Zealand
Mar 6	Dr. Hans-Joachim Pelz	Institute for Nematology and Vertebrate Research Münster, Germany

International Visitors (Continued)

Date	Name	Representing
<u>1992</u>		
Mar 6-10	Dr. Shakunthala Sridhara	University of Agricultural Sciences, Bangalore, India
Mar 10-16	Ms. Maria Elena Zaccagnini	Wildlife Management Section INTA-EEA Parana Entre Rios, Argentina
Mar 16	Dr. John Wilson	Queensland University of Technology Brisbane, Australia
Mar 24	Mr. Peter C. Nelson	Pest Management Services Ltd. Wellington, New Zealand
Apr 9, 23	Mr. Yousuf Mian	CSU Fort Collins, Colorado (Bangladesh graduate student)
Apr 27- May 20	Mr. El Hani Abderrahim Mr. Said Ghaout Mr. Arroub El Hassan	Direction de la Protection des Végétaux, des Contrôles Techniques et de la Repression des Fraudes Rabat, Morocco
Jun 6	Mr. Tony Archer	Nairobi, Kenya
Jun 8-12	Mr. Md. Emdadul Haque	Bangladesh Agricultural Research Institute (BARI) Joydebpur, Bangladesh
Jun 8-12	Mr. Lee Choon Hui	MARDI Cocoa/Coconut Research Centre Perak, Malaysia
Jun 18-19	Dra. Beatriz Villa C.	Instituto Biologica University of Mexico
Jun 23	Ms. Donna Scott	American Embassy La Paz, Bolivia

International Visitors (Continued)

Date	Name	Representing
<u>1992</u>		
Oct 29-30	Dr. Hugh Spencer	Cape Tribulation Field Study Center, Northern Queensland Australia
Nov 16-	Dr. and Mrs. Sayed Ahmed and family	Former Scientific Officer Bangladesh Rice Research Institute (now in Fort Collins, Colorado)
Nov 30	Dr. Mike Capra	Director, Centre for Biological Population Management Queensland University of Technology Brisbane, Australia
Dec	Ms. Donna Scott	American Embassy La Paz, Bolivia (transferred to Windhoek, Namibia, during the summer of 1993)
<u>1993</u>		
Dec 11, 1992 and Jan 7-15, 1993	Dr. John Wilson	Queensland University of Technology Brisbane, Australia
Mar 11-15	Mr. Robert Oudinet	Normandy Regional Crop Protection Service French Ministry of Agriculture
Mar 11-15	Mr. Patrice Prevel	Chambre d'Agriculture La Manche, Normandy
Apr 29-30	Mr. Habibur Rahman	Vertebrate Pest Section BARI, Dhaka Bangladesh

International Visitors (Continued)

Date	Name	Representing
1993		
Jun 1- Aug 31	Mr. Neil White	Centre for Biological Population Management Queensland University of Technology Brisbane, Australia
Jun 15- Sep 15	Lic. Ethel Rodriguez	Department of Bird Pests Sanidad Vegetal Plant Protection Division Montevideo, Uruguay
Jul 9	Mr. Craig Clark	U.S. Fish and Wildlife Service Brown Tree Snake Project Guam
Jul 19-23	Abdelkader Zaime	Departement de Physiologie et Thérapeutique, Institut Agrono- mique et Vétérinaire Hassan II Rabat, Morocco
Jul 23	Delegation Prof. Ma Jianzhang Mr. Zhao Zebin Mr. Zhao Kezun	People's Republic of China College of Wildlife College of Wildlife Experimental Forest Farm Northeast Forestry University Harbin, China
Jul 23-Aug 2	Dr. Mohamed Farag El-Sayed	Egyptian student on post- doctorate fellowship at Bowling Green State University Bowling Green, Ohio
Aug 30-Sep 24	Mr. Lee Allen	Lands Protection Branch Brisbane, Australia

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